NBC REPORT

U. S. Army Nuclear and Chemical Agency

Spring / Summer 2006

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Rebirth of the Nuclear Weapons Complex

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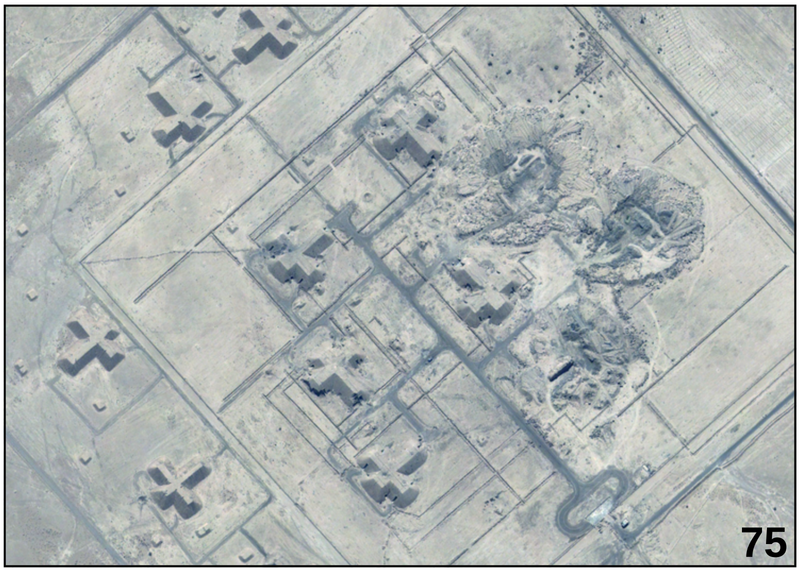

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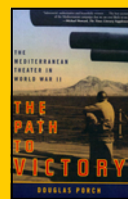

Combating WMD Resource Page

NBC REPORT
U.S. Army Nuclear and Chemical Agency

Published by the United States Army Nuclear and Chemical Agency

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USANCA's Evolution and Change

Mr. Peter Bechtel, Director
United States Army Nuclear and Chemical Agency

Mr. Peter Bechtel
Director
U.S. Army Nuclear and Chemical Agency

Changes are underway here at the U.S. Army Nuclear and Chemical Agency. On 26 April, 2006 the agency left TRADOC and became a Field Operating Agency (FOA) under the Headquarters, Department of the Army G-3/5/7 (our old "home"). As of this writing, the full implications of these changes are not certain, but what is certain is that USANCA will transform to improve the Army's role in the efforts to Combat Weapons of Mass Destruction. Our organization will be aligned to better support the warfighter and enhance the Army's efforts to combat WMD (CWMD). As the new structure, roles and missions of the organization solidify, we will keep the CWMD community informed of the process.

The agency will expand across the spectrum of CWMD, help in decision support and fill in gaps previously left open. It will leverage those centers of expertise across the breadth of CWMD, and continue to lead the Army in nuclear expertise. Colonel Brian Groft, Deputy Director, and I view USANCA as a key enabler and liaison to help bring CWMD expertise forward to the land component commander.

This publication will begin to reflect both the changes in the Agency as well as the sweeping changes taking place in the CBRN community. Across DoD, CWMD has broadened the scope of CBRN mission space. The efforts supporting it are inherently Joint, inter-agency and international in their nature. Plans, policy, doctrine, and units are transforming to accommodate the new reality. Articles solicited for publication in the NBC Report (soon to be the Combating WMD Journal) will be more expansive in scope, in order to capture the pertinent things being accomplished across this spectrum of like minded organizations that literally span the globe with their work. I ask for your help in this exchange of information and ideas.

This issue brings some new partners into the fray, with several articles drawn in from other publications. We feel that the ideas discussed are relevant and will hold interest for our readership. One excellent publication is NBC International (http://www.defenceinternational.co.uk) out of the United Kingdom. Their editor, Mr. Gwyn Winfield, has agreed to share some recent articles with us, and this partnership will hopefully continue in future issues.

The NBC Report has a venerable history, and as steward of this history we here at USANCA have a responsibility to ensure changes do not affect the quality of the product. More important, in order to keep the publication relevant it must reflect the work being done by the troops in the field. In that spirit, this will be the final issue of the NBC Report. It will surely become a collectible so hang on to your copy. The fall/winter version will be the first issue of The Combating WMD Journal, the new name reflecting the evolution of the mission.

We would also like to add some new sections to the magazine, specifically a Letters to the Editor and Photos section. Letters to the Editor will include any responses to the articles presented here, so we encourage any and all dialogue regarding the subjects presented. In the past we have published the author's email so you could write directly to them with any questions. Please include us (nca@usanca-smtp.army.mil) in your responses as the questions and comments can be value added for the larger audience and we'd like to capture them in this section. We'll encourage this dialogue as people get engaged with the subjects we present in this forum; everyone learns and thinks more, and this is certainly what we must sustain. We would also like to solicit any recent photos of CBRNE related deployments, training exercises or site visits that you'd like to share. Everyone likes to see themselves in a magazine so if you would like to get a mention of a certain event without having to write an entire article, a good photo with a caption is all we need.

One final change is at hand. As USANCA becomes aligned with the

G-3/5/7, we will develop our own web portal. The Army Combating WMD Journal, as well as some more recent back issues of the NBC Report, will be made available online in a PDF format. It's doubtful that we will ever completely do away with sending the hard copies out, but in order to minimize the production expense, please let us know if a soft copy is all you need. We'll take you off the mailing list, but you can certainly turn it back on again simply by sending us an email.

By the time the next issue rolls around, USANCA will have begun its transformation. That said, we will continue to provide the warfighter with the vital CWMD support they require and will remain the Army's conduit for things nuclear and chemical. That is one thing that will never change.

Peter B. Bechtel
Director

A Planning Construct for Combating WMD

Mr. Tab A. Blazek ANSER and CPT Matthew J. Moakler
DTRA/SCC-WMD

Successful military campaigns rely upon detailed, effective and validated plans. The campaign to Combat Weapons of Mass Destruction (CbtWMD) is no different. The development and release of the National Military Strategy for Combating Weapons of Mass Destruction (NMS-CWMD) generated a critical need across the Department of Defense (DoD) for review and, as necessary, revision of doctrine, policy and plans related to the emerging CbtWMD campaign that will enable effective planning at all levels. This strategic and operational-level review served as a key element in the subsequent development of strategic concepts, plans, and associated operational-level framework documents. These framework elements provide the necessary instruction and guidance required for drafting campaign, contingency and functional plans that will ultimately fulfill critical national and theater-level CbtWMD requirements.

What follows is a summary of the National Military Strategy to Combat Weapons of Mass Destruction and the analytic results of a detailed comparison and contrast of previous NBC defense and counterproliferation strategies with those emerging from the CbtWMD campaign development processes. An examination and evaluation of current Joint Operation Planning and Execution System (JOPES) planning formats for the NBC Defense and Consequence Management (CM) mission areas against the Military Strategic Objectives (MSOs) and revised mission areas of the NMS-CWMD will familiarize CbtWMD policy makers and planners at all levels with the new strategy elements, as well as national goals and objectives. Finally, a presentation of a revised JOPES planning framework will draw clear distinctions between this and the previous planning template and format. If adopted, this revised framework will lay the foundation for CbtWMD concept integration and planning at all applicable levels.

Introduction of New Guidance

The NMS-CWMD provides an ends-ways-means framework consisting of nine clear Strategic Endstates (ends), four Military Strategic Objectives (ways), and eight Military Mission Areas (categories for means). This framework, plus an effects-based approach to planning and operations (Figure 1) provides a solid foundation on which to do the following: develop and draft deliberate plans, coordinate and synchronize CbtWMD activities and operations across the range of agencies and organizations within the community of interest, and advocate for and acquire capabilities to implement these plans.[1]

> ***"Our military strategic goal is to ensure that the United States, its Armed Forces, allies, partners, and interests are neither coerced nor attacked by enemies using WMD."***
>
> *-National Military Strategy to Combat Weapons of Mass Destruction, February 2006*

The general theory of effects based planning can be easily applied to the guidance in the National Military Strategy to Combat WMD. Joint Force Commanders and their staffs need only to determine effects required to achieve the MSOs and then direct friendly action through existing UJTL tasks. Measures of Performance (MOP) and Measures of Effectiveness (MOE) must also be planned for and used to assess if and how

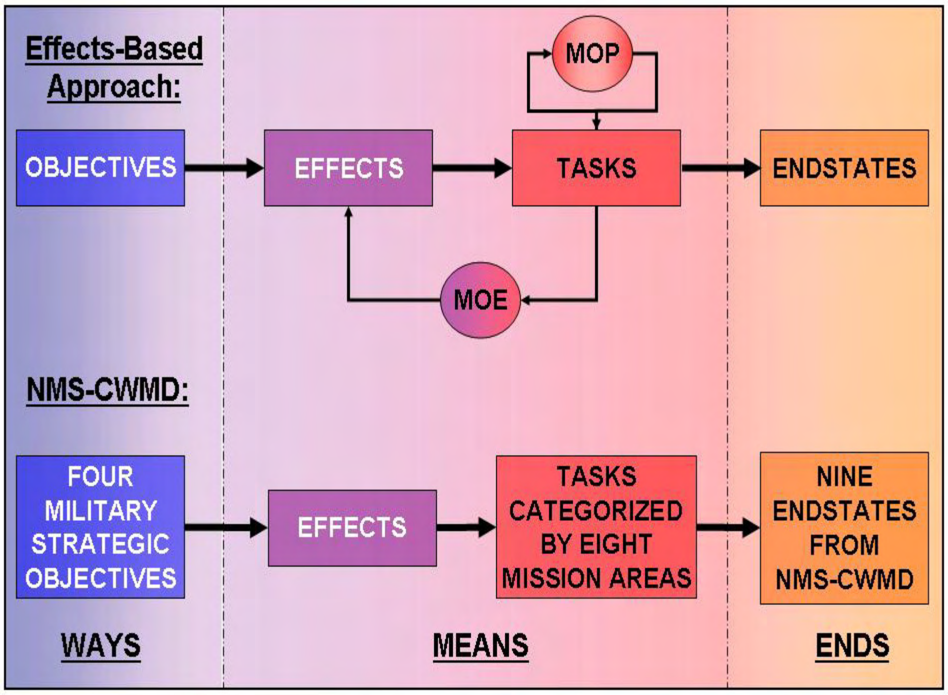

Figure 1. Effects Based Operations.

well the tasks are done and the if the desired effects are achieved.

One important element within the NMS-CWMD Effects Based Planning framework is the grouping of the eight Military Mission Areas:[2]

- Offensive Operations
- Elimination Operations
- Interdiction Operations
- Active Defense
- Passive Defense
- WMD Consequence Management
- Security Cooperation and Partner Activities
- Threat Reduction Cooperation

Since the US Armed Forces may be called upon to perform any or all of these eight mission areas simultaneously in conduct of CbtWMD operations, it would stand to reason that we have a planning format that addresses each of them.

Dated Strategy and JOPES Organization

The current *Chairman of the Joint Chiefs of Staff Manual (CJCSM) 3122.01B, 30 JUN 05 (JOPES vol. II)* does not easily conform to NMS-CWMD, but rather to the outdated Counterproliferation strategy that formed the framework used in the drafting of CJCS CONPLAN 0400-02. Within the CONPLAN 0400 construct, JOPES vol. II already recognizes Offensive Operations and Active Defense as critical mission areas for the Department of Defense, but not as they relate to combating WMD.[3]

The only elements within the current JOPES vol. II that directly relates to CbtWMD are Annex C and Annex T. Annex C, Appendix 2 (Nuclear, Biological, and Chemical Defense Operations; Riot Control Agents and Herbicides) covers passive defense aspects such as NBC protective posture and the authorization and use of riot control agents and herbicides. Annex T (Consequence Management) provides a location for WMD Consequence Management (WMD CM), but does not differentiate it from other things like disaster response, humanitarian assistance, foreign consequence management (FCM), and pre-planning for National Special Security Events (NSSE).[4] In its current form, Annex T only concentrates on FCM. It is important to mention now that Annex G (Civil Affairs) currently does not make any reference to CbtWMD. (Figure 2).

CJCSM 3122.01B, 30 JUN 05 only addresses Nuclear, Biological, and Chemical (NBC) Defense, decision authority for the use of riot control agents and herbicides, and FCM. The current format does not conform to the NMS-CWMD, nor provide a useable construct for combating WMD planning.

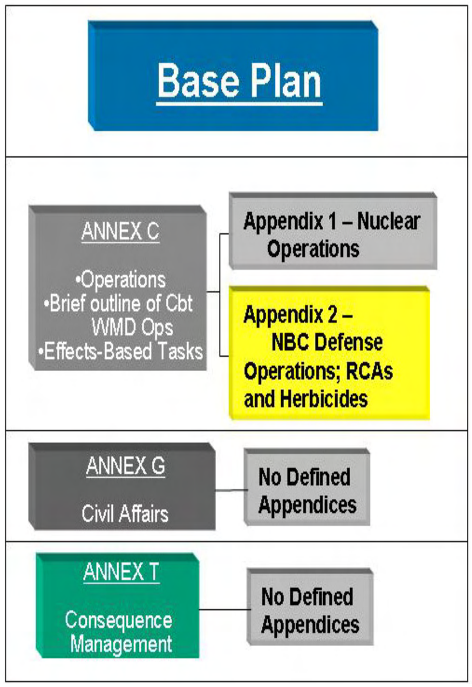

Figure 2. Current JOPES vol. II Organization Relative to WMD.

Based on a Joint Staff J7 determination that CbtWMD planning should be organized in Annex C, there are two questions that arise:

1. Where within the current appendices of Annex C does it go?

2. How can WMD Consequence Management exist in both Annex C and Annex T?

Incorporating NMS-CWMD into JOPES

The planning guidance and mission description that make up the current Appendix 2 to Annex C *(NBC Defense Operations; Riot Control Agents and Herbicides)* can easily be incorporated into the NMS-CWMD Military Mission Area of Passive Defense. It is defined as "measures to minimize or negate the vulnerability

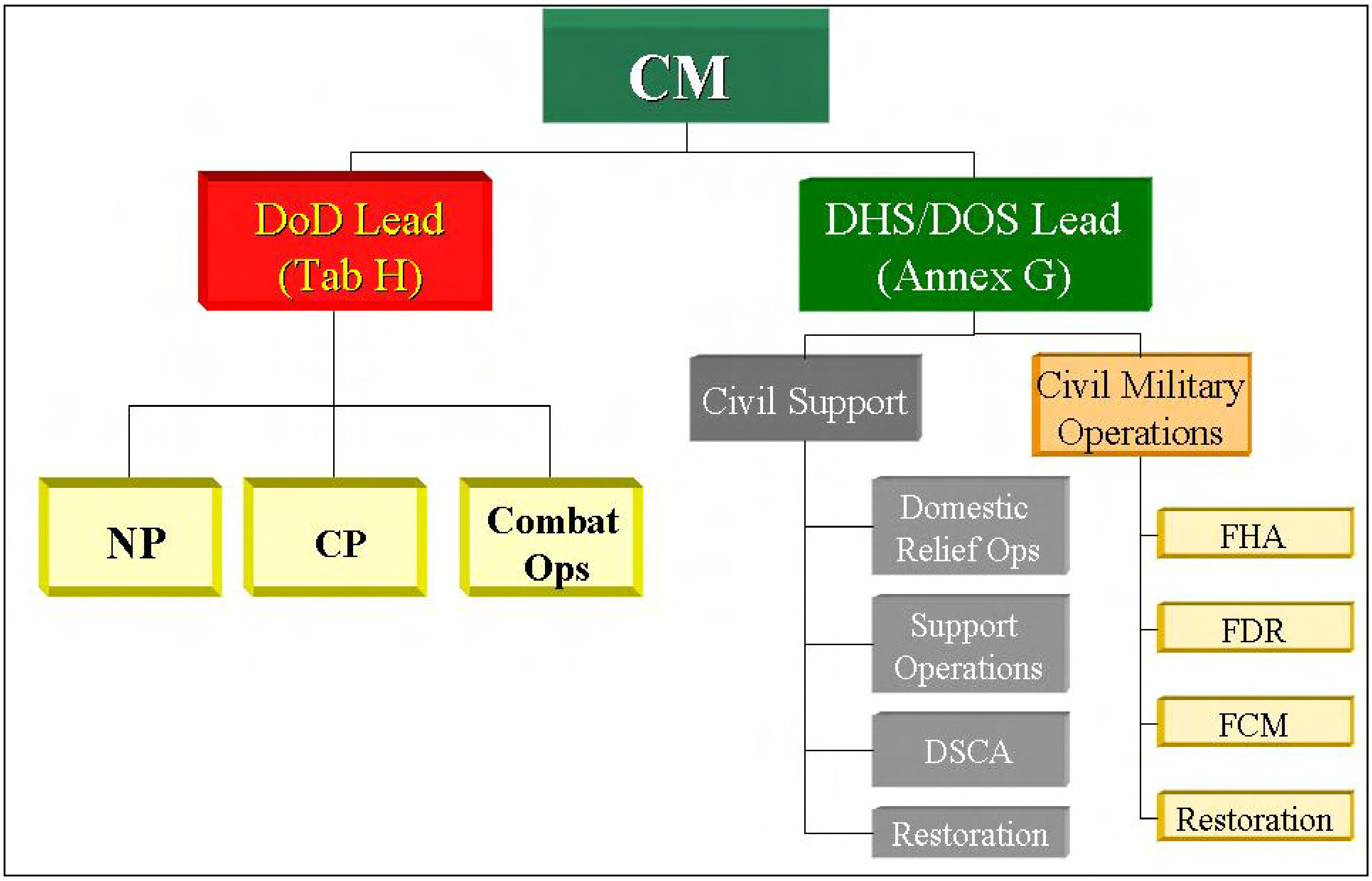

Figure 3. Functional Separation of Consequence Management. CM can be Functionally Separated by Discerning who the Lead Federal agency is for different types of missions.

and effects of WMD employed against U.S. and partner/allied Armed Forces, as well as U.S. military interests, installations, and critical infrastructure."[5] Since the CbtWMD mission is a larger scope than NBC Defense Operations, we can replace the current Appendix 2 to Annex C *(NBC Defense Operations; Riot Control Agents and Herbicides)* with the new strategy- Appendix 2 to Annex C (Combating Weapons of Mass Destruction). Since the eight Military Mission Areas support the CbtWMD mission, each can become a tab under the CbtWMD appendix. The new passive defense tab will cover the mission focus of the old appendix (see Figure 4).

Consequence Management (CM) is the other controversial Military Mission Area within the NMS-CWMD. Consequence Management itself is simultaneously a pillar in the *National Strategy to Combat WMD*, a Military Mission Area in the NMS-CWMD, and an annex in the current JOPES vol. II. As a Military Mission Area, WMD CM must be evaluated within the overall strategic concept of the NMS-CWMD and therefore be included within the Annex C, Appendix 2 construct as a tab. However, evaluating WMD CM in this construct does not allow for consideration of all potential CM situations (natural disasters etc.). To differentiate between the two conceptual elements, the authors categorized the missions based upon where the command and control relationship within which each element resides. Combating WMD CM was embedded within a structure where DoD is the lead agency. The areas that compose WMD CM were also integrated within an interagency framework where CM is conducted in support of Civil Support requirements under the Department of Homeland Security (DHS) or in support of Civil Military Operations overseas under the Department of State (DOS). Both interagency elements already reside within JOPES within Annex G (Civil Affairs).

Consequence Management itself is simultaneously a pillar in the National Strategy to Combat WMD, a Military Mission Area in the NMS-CWMD, and an annex in the current JOPES vol. II.

Placing WMD CM within either Annex C, Appendix 2, or within Annex G clarifies the type of mission support the DoD provides and the command

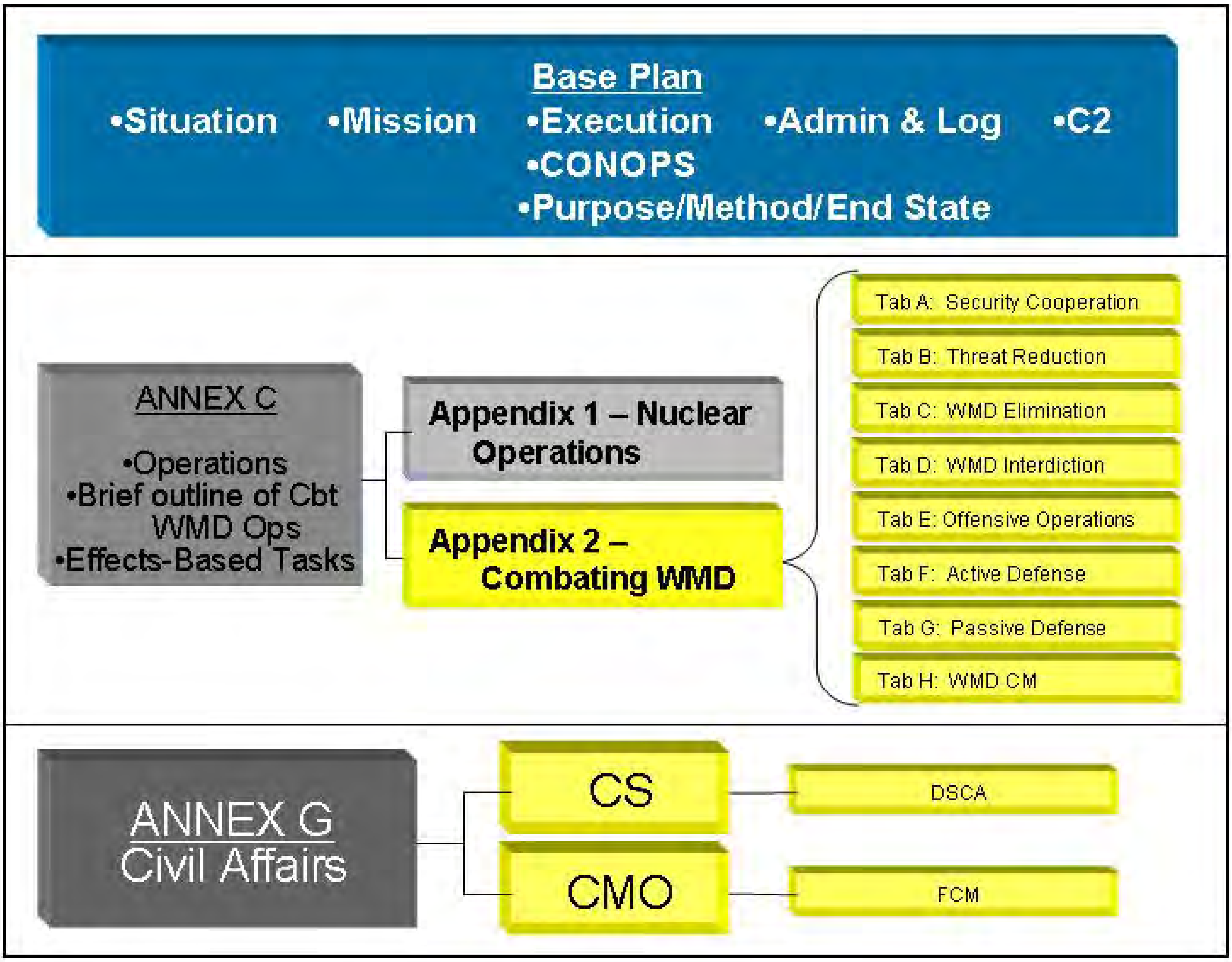

Figure 4. The Recommended Framework for JOPES vol. II Organization.

and control structure under which support is provided. Our approach to smooth some of the friction that has resulted from the development of this concept is to functionally separate incidents based on the Lead Federal Agency (LFA) that is responsible for responding (Figure 3).

Once CM is viewed from the Lead Federal Agency point of view, it can more easily be organized within the JOPES Vol. II Planning Format. When directed or authorized by the President, the SECDEF can authorize DoD support to other government agencies at home (Defense Support of Civil Authorities) or abroad (USG Foreign Consequence Management).[6] Missions such as Disaster Relief, Humanitarian Assistance, US Secret Service led National Special Security Events (NSSE), and restoration operations are other examples that DoD provides support to but is not the Lead Federal Agency. All of these examples can be categorized as either Civil Support Operations or Civil Military Operations within Annex G (Civil Affairs).

Conclusion

Current and future development of the national Combating WMD CONPLAN and subsequent COCOM support plans depends upon a rational and well developed approach to organizing critical CbtWMD mission areas within the recognized JOPES vol. II format. The organization of this format is critical to capturing the integrated nature of the CbtWMD strategy. It is because of this integration that the prescribed JOPES vol. II format includes a comprehensive Combating WMD Appendix that includes Tabs for each of the CbtWMD Mission Areas (see Figure 4). We recognize the unique requirements inherent to WMD CM and address those requirements through a methodical separation of support requirements based upon command and control relationships. This separation is reflected in a highly developed Annex C, Appendix 2, Tab H (WMD CM) as well as Civil Support and Civil Military Appendices of Annex G. Both elements will extensively use linkages and references to lead planners through the complex planning steps that are characteristic of this complicated mission area.

What results from all of this is a JOPES vol. II format that supports more effective operationalization and articulation of the NMS-CWMD. As

the national strategy has matured and developed, so too must the planning formats used to translate this strategy into viable and effective military plans.

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ENDNOTES

[1]Chairman of the Joint Chiefs of Staff, “National Military Strategy to Combat Weapons of Mass Destruction”, 2006 at 4.

[2]Id. at 22-27.

[3]Chairman of the Joint Chief of Staff Concept Plan 0400-02, “Counterproliferation of Weapons of Mass Destruction (U)”.

[4]Chairman of the Joint Chiefs of Staff, “Chairman of the Joint Chiefs of Staff Manual (CJCSM) 3122.01B, Joint Operations Planning and Execution System (JOPES) Volume II Planning Format”, 2005 at E-T-1 to E-T-8.

[5]Chairman of the Joint Chiefs of Staff, “National Military Strategy to Combat Weapons of Mass Destruction”, 2006 at 25.

[6]Chairman of the Joint Chiefs of Staff, “National Military Strategy to Combat Weapons of Mass Destruction”, 2006 at 26.

Symphony or Cacophony? Mastering the Challenge of Combating WMD: An Analysis

MAJ Bret Kinman
United States Joint Forces Command

Weapons of Mass Destruction (WMD) present a continuing challenge to both policy makers and military planners.[1] These types of weapons represent a range of possibilities from the large-scale physical destruction found in nuclear weapons, to the more prolonged human impact of a chemical or biological weapon. WMD are a legacy of the immense technological progress achieved in the 20th Century and remain one of the enduring security challenges in the 21st Century. While most WMD are addressed in existing international treaties and accords, these agreements were achieved by the major powers in the latter half of the 20th Century, in most cases against the backdrop of the Cold War.

The threat of these weapons remains and can be expected to grow from those states and entities not part of, or not adhering to, the existing political agreements regarding WMD. To address this security challenge, the Department of Defense (DoD) has begun to clarify its roles, organizations, and functions in this area. For the Joint force, the new mission area is known as "Combating WMD" and this new mission will present a diverse set of tasks for the Joint force to accomplish. Success will be a joint force organized, trained, equipped, and employed to combat these threats in a coordinated way- a symphony. Failure will be disparate, stovepiped, uncoordinated capabilities that are unable to effectively support Combatant and Joint Force Commanders (JFC) - a cacophony. This essay will review the major threats posed by WMD, provide an overview of the recent history of efforts to reduce WMD, outline the major concepts and associated tasks of the "Combating WMD" mission area, and offer some ideas on how joint planners need to approach this mission.

Current WMD knowledge and experience spans a variety of expertise, from the legacy of Cold War challenges posed by the Former Soviet Union (FSU), to include large nuclear, biological, and chemical stockpiles, to the emerging challenges in China, South Asia, and Middle East and with terrorist groups. Much like any specialized community, the WMD community operates with its own sometimes confusing lexicon. So, in order to orient readers to a common understanding, a primer of basic concepts and terms is essential.

First principles are key - the main function of the combating WMD mission is to ensure the security of the United States (US), its allies, and its interests from threats of these weapons. The effort must address, the weapons themselves, the industrial infrastructure that can produce the weapons, the supporting materials and human capital (with the technical and operating knowledge to design, construct, and employ these weapons), the networks that transport this material, and if necessary, the ability to manage the consequences of their use. The efforts to Combat WMD are detailed in Joint Publication 3-40 as three pillars: Nonproliferation, Counterproliferation, and Consequence Management.[2] Traditionally, these areas have been managed by different government organizations, to include the DoD, Department of State (DoS), Department of Energy and a number of other government departments and agencies.

Nonproliferation represents those efforts undertaken to control, account, and secure WMD and related programs. Nonproliferation is normally conducted under the auspice of treaties or other agreements, and it is not done in hostile or uncertain operational environments. Counterproliferation represents proactive efforts taken to secure WMD or prevent their movement or development. This effort also focuses on halting the movement of WMD weapons, material, technology, and human capital.

Counterproliferation actions are not necessarily covered by a specific treaty or agreement, although the Proliferation Security Initiative (PSI) is a loose, non-binding agreement by a number of nations to conduct or support these activities.[3] Finally, Consequence Management encompasses the efforts taken to respond to the use of WMD. This is not normally a DoD led effort; rather DoD supports either the Department of Justice (DoJ) if the incident is domestic, or the DoS if the incident occurs overseas. The DoD maintains the specialized equipment and technical

knowledge to deal with contaminated personnel or material, and also conduct WMD sample identification, transport, and laboratory analysis.

With the dissolution of the Soviet Union in 1991, initial efforts began in order to ensure the FSU had adequate control of its WMD programs. That early work focused on identifying and securing the vast amounts of WMD-related material and associated production capability across the FSU weapons complex. US efforts continue, and initiatives such as the Nunn-Lugar Act, commonly referred to as the Cooperative Threat Reduction (CTR) program, have been relatively successful in reducing the stockpiles of these weapons and delivery systems. The Nuclear Cities Initiative redirected former Soviet weapons workers into more peaceful applications. Diplomatic efforts after the breakup of the FSU persuaded the Ukraine and Belarus to surrender their legacy Soviet nuclear weapons and delivery systems. Further, efforts associated with the Nuclear Nonproliferation Treaty (NPT) in the late 1960s and early 1970s deterred Argentina and Brazil from developing nuclear weapons. The US has more experience in nonproliferation efforts than the other two pillars of Cbt WMD.

Throughout the 1990s international efforts focused to restrain both India and Pakistan from increasing their nuclear stockpiles and improving their delivery systems. The South Asia nuclear arms race continues to cause concern for both regional and international players. The long history of conflict between these nations over the disputed Kashmir region questions the plausibility of escalation control in a nuclear exchange. Further concerns remain about the command and control of the Pakistani weapons, to include the physical control of the warheads. The revelation of the A.Q. Kahn nuclear technology black market network, which spanned much of the Middle East and South East Asia caused further concern. The exposure of this network has increased the fear of what portions of the Pakistani weapons program might have found their way to North Korea, Iran, Libya, and most disconcertingly, to Islamic extremists. Although much of the Kahn network has been dismantled, it is quite possible that some parts remain active? Interestingly, Libya surrendered its WMD programs in return for the lifting of UN sanctions and reintegration with the European and international economies. Other efforts have continued to restrict the international movement of material, technology, and in some cases, intellectual talent, related to WMD. Examples include the Missile Technology Control Regime and the London Nuclear Suppliers Group[4] as well as the longstanding NPT, which was signed in July, 1968.[5,6] These efforts have had more success than failure over the duration of their existence, but they are products of the 1960s and have had their impact on the nations they were intended to restrain from a nuclear weapons program. Other treaty regimes such as the Chemical Weapons Convention (CWC), signed January 1993, and the Biological Weapons Convention (BWC), signed April 1972, have focused mainly on post Cold War adversaries and their biological and chemical weapons programs.[7] However, the CWC and BWC solved past challenges and their ability to curb the current Russian chemical and biological weapons programs is still in question.[8]

Finally, the two nations that continue to pose both policy and practical challenges to the US and the international community are North Korea and Iran. Both countries have dodged international monitoring and verification efforts while continuing to pursue or refine nuclear weapons. North Korea has withdrawn from the NPT and expelled International Atomic Energy Agency (IAEA) inspectors and monitors. Iran continues negotiations with Britain, France and Germany, while occasionally complying with IAEA inspectors. North Korea has attended the "Six Party" (China, Japan, South Korea, Russia, United States, and North Korea) talks while advocating unacceptable demands for bilateral negotiations with the US. The true status of each country's program is unknown. These two nations represent much of the future challenge for US and allied efforts to combat WMD.

In view of these ongoing concerns, the DoD and the military Services have begun to look at what the requirements are and what major decisions are needed to meet these challenges. As outlined above, the challenges from WMD have expanded in spite of international efforts to control their spread. Further, the shift in threat from major states to non-state actors has required a change in thinking about how the US needs to address this threat. Clearly, Cold Warera arms control is inadequate for restraining al-Qaeda. Moreover, an increasingly globalized world with improved technology has reduced the physical production requirements for many WMD. So how does the US improve its ability to defend the homeland and protect its other interests from WMD wielding terrorists?

Recent experience in OPERATION IRAQI FREEDOM (OIF) saw the US military under- prepared to locate, characterize, and secure the large stockpiles of WMD, specifically chemical and biological weapons, the Iraqi regime was expected to have. This shortfall was the result of disparate defense organizational structures and associated functions for units that deal with WMD, as well as limited equipment and training. Subsequently these units were faced with a new and unprecedented mission - finding and securing stockpiles of dangerous weapons under combat conditions. The WMD search and recovery effort in OIF was centered on the 75th Field Artillery Brigade, an active duty unit, consisting of two Multiple Launch Rocket System (MLRS) Battalions and one M109A6 "Paladin" cannon battalion, which was given the mission to perform as an Exploitation Task Force (XTF).[9] The 75th XTF and its associated elements performed admirably under difficult conditions including: limited training time, challenging tactical security requirements, shifting command arrangements, and limited amounts of technical equipment. However, the bottom line remains that the US military was forced to create a "pick-up" team to perform an extremely impor-

tant and risky mission.

There is also an increased awareness of the possibility of WMD being transported into the US or an allied country by terrorists. An increasing level of effort is needed to search vessels, aircraft or cargo, not only in or near the US but also in allied and other nations. Unsecured materials, industrial production capability and equipment, and technical knowledge all generate a range of possible outcomes if left unmonitored; each detrimental to the US and its allies. The demands of the Global War on Terrorism (GWOT) have placed a premium on the Special Operations forces available for many missions, such as specialized training and equipment needed for searching a vessel or aircraft. Finally, WMD being utilized in a terrorist attack and the associated aftermath may call for specialized DoD responsive capabilities to identify and transport WMD material and assist in the clean up. This requires a broad set of capabilities which would need planners and other staff to properly plan and execute these operations.

In this light, the DoD has codified what it terms the "Combating WMD" mission area. While many of the particulars remain to be fully defined, it is safe to say this decision is intended to align the disparate DoD organizations, activities, policy, and processes in dealing with WMD; and perhaps most importantly, provide National Security policy makers with a coherent set of options to rely on when dealing with WMD. As stated earlier, the DoD construct for the combating WMD mission has three main pillars: Nonproliferation, Counterproliferation, and Consequence Management. These three pillars are further supported by eight sub-tasks or military missions: Security Cooperation & Partner Activities, Threat Reduction Cooperation, Interdiction, Elimination, Offensive Operations, Active Defense, Passive Defense, and Consequence Management. To further clarify, those eight missions are generally defined as follows:[10]

Security Cooperation & Partner Activities - Activities to improve partner and allied CBRN defensive capabilities through military-to-military contact and support to treaties and agreements as directed.

Threat Reduction Cooperation - Activities undertaken with the consent and cooperation of host nation authorities to enhance physical security, reduce, dismantle, redirect and/or improve protection of a state's existing and legitimate WMD program and capabilities.

Interdiction - Operations to stop WMD, delivery systems, and associated technologies, materials and expertise from transiting between states and between state and non-state actors of proliferation concern.

Elimination - Operations to locate, characterize, secure, disable and/or destroy a state or non-state actors' WMD programs and related capabilities in a non-permissive environment.

Offensive Operations - Kinetic and/or non-kinetic operations to defeat, neutralize, or deter a WMD threat or second use of WMD.

Active Defense - Military measures to prevent or defeat the delivery of WMD. Measures include offensive and defensive, conventional or unconventional actions to detect, divert, and destroy an adversary's WMD and/or delivery means while en route to their target.

Passive Defense - Measures to minimize or negate the vulnerability and minimize effects of WMD use against US and coalition forces as well as US military interests, installations, and infrastructure.

Consequence Management - Actions taken to mitigate the effects of a WMD attack or event and restore essential operations and services at home or abroad.

The combating WMD construct is a much needed integration of many disparate efforts, programs, and policies. While many of the details and decisions are still being considered, the effort is gaining needed attention to empower decision makers and planners with useful options. Of course, defining the mission is only a partial solution, it is still necessary to articulate the specific requirements for the Joint force and develop both the capabilities and allocate the required resources needed to execute this mission.

At first glance, the mission of combating WMD seems to only require a discreet set of technical experts and specialized equipment in order to be effective. However, proper execution of the broad set of tasks outlined above will require much more than that. The experience of the 75th XTF in OIF saw a requirement for about 200 soldiers, not counting the addition of various experts in a variety of fields. By contrast, the manpower needed for treaty inspections and visits in the FSU do in fact need only small numbers, typically 10-15 members of technical experts. The consequence management mission could also conceivably require large total numbers, perhaps as much as 10,000 personnel depending on what type of incident had occurred and in what environment, such as a nuclear detonation in a large city.

Beyond total numbers, there is a significant requirement for technical expertise. A key point here is that not all WMD are equal, so technical knowledge is specific to what WMD one is dealing with. Experts capable of dealing with chemical weapons and materials may have some familiarity in dealing with biological weapons and material, but to assume a one-for-one exchange in subject matter expertise is faulty. The skills required for dealing with nuclear weapons and materials are another, completely different skill set. The unfortunate fact is that the amount of this type of expertise among deployable DoD units in the is extremely limited and not very well coordinated. Future operations may require more than one set of expertise to tackle more than one type of WMD problem, so growing these skills within the DoD is of paramount importance.

As an example of how we are expanding these skills, the Army has a Chemical Corps which specializes primarily in chemical and biological weapons but also nuclear and radiological weapons. The Corps provides WMD expertise down to the battalion level and retains a focus on battlefield chemical and biological weapons use. These skills are backed up by the

Army's Functional Area 52 (Nuclear & Counterproliferation) officers who focus on nuclear physics and WMD policy and plans. In light of the emerging shift in threats, the Army is making significant adjustments. For instance, the Army has established the 20th Support Command (CBRNE), which is focused on WMD threats, and is developing a robust set of deployable technical experts and laboratory capabilities able to support JFCs around the world.

The Marine Corps has the Chemical Biological Incident Response Force (CBIRF), a dedicated set of experts and equipment that is rapidly deployable to an incident site. The Air Force and Navy also have some smaller, similar sets of capabilities and personnel skill sets appropriate to the needs of their Services. Each Service also has capable medical and health surveillance capability, which supports all aspects of the combating WMD mission. Finally, the Defense Threat Reduction Agency (DTRA) retains a set of WMD related skills based upon its longstanding missions in WMD treaty enforcement and inspection, anti-terrorism and WMD-related research.

However, the efforts of these units and agencies are not synchronized, and the exact capabilities, training, and equipment they possess are not widely known outside of their respective organizations. Additionally, some of the examples above are small, low density-high demand units, and made up in some cases of individuals who form teams only when needed and still retain "day jobs." Hence the wisdom behind the codification of the combating WMD mission, and the need to identify, organize and synchronize the DoD WMD capabilities to better support the JFCs.

The threats and challenges of WMD articulated above will remain one of the US enduring realities for some time. The DoD has taken positive steps to address this, yet more must be done, and in this instance time is not on our side. The DoD is currently conducting the Quadrennial Defense Review (QDR), which is a large scale review of the DoD's roles, functions, and missions. The QDR process looks at key recommendations about the DoD, which are then considered, debated, analyzed, and finally, decisions are taken about the future size, structure and skills of the US military. In addition, the Joint Staff, Combatant Commands, Services and DTRA are hard at work on developing useful guidance, defining the overall priorities, and organizational needs for the combating WMD mission. With that in mind, a few points for overall consideration are offered:

Focus on the Entirety of Combating WMD

The desire to focus only on one specific combating WMD task or another is counterproductive. For example, the task of elimination is clearly land power centric. Yet the Army should not become the basis for all subsequent decisions on how to structure and plan to execute this mission. The need for a broad focus on the entirety of combating WMD is also essential as organizational and structural decisions are made to support this. Overly focusing on one or two tasks may drive faulty decisions that result in an imbalanced capability, inadequate to the broadest set of tasks. Some aspects of this mission are already mature or some experience is resident within the military and this experience can provide insight to the other aspects of combating WMD. Combating WMD has three focus pillars and eight tasks; this construct is entirely adequate for organizational and planning purposes. Consequently, this construct, in its entirety, should remain the basis for organizing and executing this mission.

Change will be Inherent

The threats from WMD will continue to evolve, science is not static, nor are those who wield it. With that view, we must be willing to accept a change of course when necessary. The process imperatives of the DoD and governmental budget systems drive us to predictability and stability in our force training, planning and capability development. This system remains, despite constantly changing reality. The need for alterations in force structure and capability may often be off phase with the latest programmatic cycle or planning and budgeting schedule. Our enemies are not bound by the restraints of the Joint Capabilities Integration Development System (JCIDS) or similar programmatic methods. Finally, the JFC cannot wait on resourcing and acquisition systems to "spiral-in" a capability he may need now.

Retain Flexibility of Thought

The combating WMD missions may require novel solutions to adequately execute, especially given the ongoing commitments in Afghanistan, Iraq, and defending the homeland. The Army generated one such solution by taking a unit such as the 75th Field Artillery Brigade and retasking it for a mission it would never have considered itself organized, trained, or equipped to execute. Yet this sort of thinking is where the future lies. The above statement is not advocacy for this specific solution as precedent, rather intended to show the scope of how we must approach this mission. Tasking a unit such as a Field Artillery Brigade or similar sized unit with a so-called "Second METL (Mission Essential Task List)" may be one solution. The details of this notion will need to be further studied and weighed against other possible solutions, but the days of single skill units seem to be evaporating, and the need for "multi-taskability" in units is more apparent than ever.

Of equal imperative is the need for properly structured headquarters and staff elements to develop and maintain the "day-to-day" needs of this mission. For instance, geographic Combatant Commands should be permitted to create an appropriately sized staff element within their J3 or J5 that focuses solely on the combating WMD mission and its three major pillars. As an example, PACOM's needs are diverse, encompassing a large maritime expanse for interdiction efforts, and a certain key focus area in North Korea for possible offensive operations and elimination

actions. In any case, this staff element should be an appropriate mix of military and civilian operators and planners, able to address all three combating WMD pillars and its eight associated mission areas while being robust enough to support surge requirements for combating WMD, such as support to a Joint Task Force, and the “steady state” operations required of all staffs. Similarly, functional Combatant Commands should consider staff adjustments appropriate to their specific mission. Service components of geographic Combatant Commands should also review suitable realignments of their staff structure to incorporate this mission. Finally, the Services will need to embrace this mission, as it is not going away, even as it is now in its nascent stages. Combating WMD expertise cannot be fashioned overnight, and it will require a broad commitment to improving and perfecting all aspects of military art and science as related to this mission. A properly structured interagency support function with the necessary authorities will be essential and will go a long way towards integrating combating WMD activities that are occurring outside of DoD.

This paper has reviewed the enduring threats posed by WMD and terrorism and the effort of the DoD to address it. The combating WMD mission area with a few exceptions, is in the early stages of development, so bureaucratic roadblocks and resistance to change have not become fully apparent. As such, the thoughts provided are intended to provide guiding intellectual tenets for planners, rather than specific recommendations or opinions of what mission is more important, or what structure or equipment is needed. There are already scores of these opinions out there. Policy makers and military planners must make numerous decisions, each with impacts, positive and negative, in order to effectively structure the US military to combat WMD. These decisions and the underlying tenets of the thinking behind them will be what determines either the creation of a coordinated symphony or of a dissonant, cacophony, in the US approach to combating WMD.

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ENDNOTES

[1] Authors Note: For this analysis, WMD refers to Nuclear, Biological, Chemical and Radiological type weapons. I have intentionally not included High-Explosive weapons. However, some doctrinal and policy documents make this inclusion. There are advocates on both sides of this debate. My exclusion of High-Explosive weapons is done to provide a better focus on a specific set of weapons that have more diverse effects.

[2] National Strategy to Combat Weapons of Mass Destruction, December, 2002

[3] The Proliferation Security Initiative or PSI is a multi-national effort to halt the spread of WMD and associated materials. Participating nations conduct training, exercises, conferences, share information and intelligence and as needed conduct actual operations to halt the air, land or sea movement of WMD. For more information go to: www.state.gov

[4] T.V. Paul, Richard Harknett, & James Wirtz, Editors, *The Absolute Weapons Revisited: Nuclear Arms and the Emerging International Order*, 2000, Ann Arbor, The University of Michigan Press, p.

[5] J. Christian Kessler, *Verifying Nonproliferation Treaties: Obligation, Process, and Sovereignty*, 1995, Washington D.C. National Defense University Press, p. 34

[6] Information on the export control regimes can be found at:
MTCR: www.mtcr.info/english/index.html
London Nuclear Suppliers Group: www.nuclearsuppliersgroup.org/

[7] J. Christian Kessler, *Verifying Nonproliferation Treaties: Obligation, Process, and Sovereignty*, 1995, Washington D.C. National Defense University Press, pp. 54 & 79

[8] National Defense University Center for Counterproliferation Research, *At The Crossroads: Counterproliferation and National Strategy,* Washington D.C., National Defense University Press, April 2004, pp.6-10

[9] LT David Gai, The Anatomy of the Hunt for Weapons of Mass Destruction, US Army Nuclear & Chemical Agency NBC Report, Springfield, VA, Fall/Winter 2003, p.11-13.

[10] These definitions are taken from both the FIANL DRAFT of the National Military Strategy to Combat Weapons of Mass Destruction, JP 3-40 “*Joint Doctrine for Combating WMD*” and the authors ongoing work with the Joint Staff J5, COCOMs, DTRA and Services.

Radiological Dispersal Devices

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The possibility of a terrorist incident involving the use of a radiation dispersal device (RDD) is of great concern to CBRNE response planners. Besides its consequences in terms of medical care requirements, human suffering, and loss of life, an RDD could tremendously impact the commerce and economy of the affected area, contaminate the environment, and generate costly cleanup and disposal issues.

One of the "best" radioactive isotopes for an RDD is cesium. Its long decay half-life, relatively high energy gamma and beta emissions, chemical properties, and relative availability make it a particularly tempting source for terrorists to use in an RDD. The approaches to managing the consequences of a cesium RDD are applicable to most other isotopes as well. Accordingly this paper will focus on a cesium RDD.

History of Uses

Although as of this writing no cesium RDD has actually been used, realistic threats have already been made. In 1995 Chechen terrorists planted a container with a few grams of cesium-137 (^{137}Cs) inside Ismailova Park in Moscow, Russia. They informed the news media, who found the device. No one was harmed. In June 2003 police in Georgia found ^{137}Cs and strontium-90 in the trunk of a taxi. The driver had no idea of the true nature of his cargo; he said he was supposed to turn it over to two men at a train station.

The largest radiation accident in the Western Hemisphere occurred in Goiânia, Brazil, in September 1987, less than a year and a half after the only larger radiation accident in the world, Chernobyl. Almost 1400 Curies (Ci) of ^{137}Cs were found in an abandoned medical radiation treatment machine that two men had unwittingly torn apart to sell as scrap metal. They found a bright blue powder inside, and brought it into their neighborhood. Some of the children, and adults as well, rubbed it on their bodies. A six-year-old girl also ate a sandwich while her hands were contaminated with the cesium. The true nature of this powder wasn't discovered for another week. Eventually this catastrophe caused almost 110 persons to be contaminated with more than 0.1 Gray (Gy). (125,000 people were surveyed in all; 249 were positive. Half of these had contamination only on shoes and clothing.) Fifty-four people had to be hospitalized for further tests or treatment. The 21 most seriously irradiated received doses ranging from one to seven Gy. Four of these died, including the six-year-old. She is the only person known to have died from acute radiation syndrome due to accidental ingestion of a radioactive isotope. Tons of homes, furniture, and soil had to be destroyed or dug up and placed in concrete lined drums for disposal as nuclear waste. The psychosocial consequences were also devastating. Cars with Goiânia license plates were stoned, and persons from Goiânia were denied airplane tickets or hotels outside the region, for many years afterward.

Table 1. Number of Persons Affected by Goiânia Accident.

Situation	*Number Affected*	*Per Cent of Population*
Screened from 30 Sep – 21 Dec 1987	125,800	100%
Contamination detected	249	0.2%
Contamination on clothing, shoes only	120	0.1%
Internal/external contamination of person	129	0.1%
Required hospitalization	20	0.02%
Number of patients with symptoms that could have been caused by radiation	5,000 (of first 60,000 seen)	8% (of 60,000)

Characteristics of Cesium

Cesium-137 is a radioactive alkali metal that is used widely in medicine (several millicuries for therapeutic radiation implants, five or six thousand Ci for irradiating blood prod-

ucts), commercial industry (up to 2200 Ci; seed irradiators in the former USSR had up to 3,500 Ci), and research (up to 20,000 Ci).

A large mobile irradiator in Beijing is said to have 250,000 Ci of ^{137}Cs. Cesium is a fission product, created by nuclear reactors or nuclear bombs.

Figure 1. Industrial Cesium.

A gram of pure, freshly made radioactive cesium emits 86.6 Ci/g; therefore the 1400 Ci in Goiânia would have weighed roughly half an ounce. (The total amount actually weighed more, as much of the cesium had decayed by the time the men tore the abandoned source apart.) Commercial industrial sources in the USA (2200 Ci) would still be less than an ounce. Even the huge mobile irradiator in Beijing would have less than 3 kg (slightly over 6 pounds) of active material.

Cesium is generally found in compounds such as cesium chloride, the most common compound for industrial use. During its decay to non-radioactive barium, ^{137}Cs emits a relatively high-energy gamma ray (0.662 MeV) along with beta particles with an average energy of 0.157 MeV. It can therefore cause skin burns, as well as damage to deep tissues in the body. Its long half-life (30 years) means that ^{137}Cs can persist in the environment as a hazard for a very long time. Most cesium compounds are readily water-soluble and can enter the body via inhalation, ingestion, or absorption through a wound. The cesium is then distributed throughout the entire body, particularly muscle; very little is found in the fatty tissues.

Figure 2. Medical Cesium.

Its long half-life (30 years) means that ^{137}Cs can persist in the environment as a hazard for a very long time.

Effects of Cesium in an RDD

Dissemination can be by means of: explosive materials (a radiological dispersal device, or RDD, often called a “dirty bomb”); contamination of food and/or water; a large hidden source; and the aerosolized dispersion of a finely ground powder of a ^{137}Cs compound.

Fortunately the explosive materials in an RDD generally disperse the ^{137}Cs over a broad enough area so that it is no longer concentrated enough to cause severe acute radiation disease. However, persons in the area will be contaminated by particles landing on their clothing and skin. Should they be close enough to the blast to be injured, radioactive particles can contaminate open wounds, embedded in the skin; contamination in the wound is more difficult to remove than external contamination. They will also be exposed to radiation from ^{137}Cs ground fallout (“groundshine”).

One hazard from an RDD would be skin contamination by dispersed ^{137}Cs. The individual might be unaware that the explosive device had blown radioactive dust onto his skin and clothing, and leave the area without undergoing decontamination. These “hot” particles could cause skin burns, even through clothing, without damaging or even warming the cloth itself. If the individual had been contaminated by 10 µCi/cm^2 of ^{137}Cs, he would be receiving roughly 0.53 Sieverts(Sv)/hr; the threshold dose for skin blistering is around 15 Sv, this would mean that if the patient didn’t shower for slightly over a day, he could get a blister. Skin redness (erythema) occurs at much lower doses, and skin ulceration and necro-

sis at higher levels. Paradoxically, the person most likely to get a skin dose high enough to cause injury would be someone relatively close to a low-yield explosive RDD. If high-yield explosives are used, a person near the device would be injured and undergo treatment and decontamination. For a person far away the RDD would disperse the ^{137}Cs into low concentrations. ^{137}Cs contamination on clothing would reduce the skin dose by roughly one fourth.

Calculation of the radiation exposure from ground fallout is relatively straightforward: dose = measured dose rate x time in area. This accounts for gamma rays only; beta radiation exposure estimation requires complex Monte Carlo computer calculations. However, due to the lower energies of the beta rays and the fact that air attenuates beta radiation more than it does gamma, the beta dose would be much less than the gamma.

One plausible RDD scenario: the Armed Forces Radiobiology Research Institute (AFRRI) hypothesized the use of a 40 TBq (~1100 Ci) ^{137}Cs source (slightly less than the amount in Goiânia) that was dispersed with 10 pounds of high explosives. Wind parameters were such that the plume traveled two city blocks in 10 minutes. At 200 yards the contamination level would be 160 mSv/year (16 rem). At 3 miles the dose level would be only 1.5 times normal background. The maximum annual occupational dose is 50 mSv. Even though no one would develop clinical symptoms at a dose of 160 mSv, even if given all at once, the impact of interruption of commerce, extensive screening, property loss, decontamination and cleanup, waste disposal, and reconstruction and relocation would be prohibitive. The increase in the risk of a fatal cancer from this dose, spread out over a year, would be much less than one percent; however, there would be a considerable fear factor.

Terrorists could contaminate the food and/or water systems with radioactive cesium. High doses of cesium can cause nausea, vomiting, diarrhea, heart arrhythmias and, in extremely high concentrations, can depress the bone marrow, causing anemia, hemorrhage, infection, and death. However, it is unlikely that ^{137}Cs would be used in this manner; if terrorists have that much, they would be more likely to use it in an RDD. And there are more lethal poisons that cause less risk to those administering them than handling this much ^{137}Cs would.

The greatest risk of ^{137}Cs to life and health, in terms of effectiveness in causing radiation injuries, would be from a hidden source. At one meter from a 600TBq (1620 Ci) source, as used in certain industrial applications, the dose rate would be 6 Sv/hr. In one hour, a person would accumulate enough radiation to cause severe acute radiation syndrome. With the best of modern medical care, an otherwise healthy person would have roughly only a 50/50 chance of surviving more than two months at this dose.

The basic principle of all medical treatment involving cesium-contaminated patients is that life-saving emergency treatment takes priority over decontamination. It is extremely unlikely that the patient will have enough ^{137}Cs in wounds, skin, or internally to constitute an acute risk to himself or the medical staff.

Inhalation and aerosolization of ^{137}Cs particles can occur in many situations. For instance, in nuclear facility accidents, as happened at Chernobyl, and in the stirring up of fallout by personnel and vehicular traffic, as happened after the accident in Kyshtym, Russia where an underground tank storing radioactive wastes exploded in 1957. The internal dose absorbed will depend on several factors:

- Particle size; particles between 1 and 5 microns can be absorbed into the lungs. Larger particles are screened out in the upper respiratory tract, and smaller tend to stay in the air.
- Airborne concentration. Again, the more dispersing explosive used, the farther the dispersion of ^{137}Cs and the lower its concentration.
- Breathing rate and lung volume. Injured and working (e.g. first responders) persons tend to breathe faster.
- Time spent in the area.

Dose calculation is complex and requires health physics support. A quick rule of thumb is that the dose rate, in Sv/hr, equals 5.76 x 10^{-9} times the concentration in Bq per cubic meter (m^3) of air. The EPA guidance is that sheltering and/or evacuation of the affected area should be done if the total dose will exceed 0.02 Sv. (Almost all persons with a dose of 2 Sv, or 100 times this amount, survive with good medical care.) Assuming a breathing rate of 1.2 cubic meters/hr, this means that the airborne concentration would have to be 3.5 x 10^6 Bq/ m^3; this is about 95 μCi/ m^3, a very high concentration. Although theoretically possible, it is unlikely terrorists would attempt to aerosolize ^{137}Cs as a primary means of weaponization.

Prevention/Interdiction

As of 1998, the International Atomic Energy reported 53 incidents of illegal cesium trafficking, 22.6% of the total seizures of radioactive materials. Fortunately cesium, in quantities with high enough activity to cause significant radiation injury, is generally easily detectable at remote dis-

tances and very difficult to transport safely. The cesium powder in the Goiânia incident, even after being dispersed through several homes in the neighborhood, was detectable by health authorities reportedly several blocks away. Survey for hot spots was carried out by helicopters. Portable survey instruments, including Geiger-Mueller (GM) counters, sodium iodide (NaI) scintillation detectors, and gamma-ray spectrometers, are available. The latter is preferred in the field because of its energy selectivity and detection sensitivity.

It is much preferable to interdict the movement of radiological materials that are meant for illicit purposes, before they can be used. A variety of detectors can be used whether fixed or portable or whether gross count or spectroscopic. The key, however, is a high index of suspicion. The investigative sense of a law enforcement officer, fireman, or other hazmat personnel is much more useful than detectors alone. Radioactive materials are quite often used and moved for legitimate purposes (i.e. medical supply shipments, the nuclear fuel cycle, research, and industrial purposes, among others) and a detector can not determine the legitimacy of the purpose; only an investigator, who considers the total situation, can do that.

Response to an RDD

First responders (police, firefighters, medics) to an incident involving an RDD may not be initially aware that a radioactive isotope such as cesium was released. With an RDD, there are legal and national security concerns involved, and the FBI will need to be informed. However, according to the National Response Plan, rescue and life-saving procedures generally take precedence over law enforcement and investigative work once an incident has occurred.

Initially first responders should use an all-hazards approach and respond in Personal Protective Equipment (PPE) Level A (civilian), MOPP4 (military), or equivalent if an unconventional agent release is suspected. Once agent(s) have been identified and atmospheric concentrations ascertained, then downgrade to Level C. Even a surgical mask, or a wet cloth over nose and mouth, keeps 20% or more of radioactive dust from entering lungs. A dry cloth is almost as effective, and is less likely to interfere with respirations, causing the person to remove it.

Responders should beware of secondary devices, and turn off pagers and cell phones at the scene. Do not sit or lean on benches, rails, or other surfaces that may collect contaminants. Do not eat, drink, or smoke in contaminated areas; only exception is bottled or canteen water through mask portals, to prevent heat stress. There are no protective medicines against external exposure to cesium. The three key elements of protection are time, distance, and shielding. Radiation do's:

- Minimize time in radiation areas
- Maximize distance between yourself and the radiation sources when possible
- Utilize shielding (e.g. buildings, vehicles) between self and sources when possible

Prior to removal of PPE a survey of the clothing should be performed. If positive, remove PPE, decontaminate, and resurvey. After duty, shower and shampoo (no conditioner; that tends to fix particles to hair shafts). A Geiger-Muller (GM) counter should be used to survey the face, hands, and feet of anyone suspected of having been contaminated. If positive, a complete whole body survey should be done. "Strip, soap, and shower" will remove 90-95% of external (clothing, skin) ^{137}Cs contamination. If the individual is uninjured, he or she should be directed how to do this. Scrub brushes should not be used, as these tend to abrade the skin and may imbed particles. Washcloths are good to use, but they will have to be considered contaminated afterward, as well as the individual's clothing. In case of an RDD, where the individual may be injured by the blast and may have cesium imbedded or have airborne particles contaminating open wounds, the wounds will need irrigation.

Use agent detector kits, detection paper, area monitors, and radiation survey meters available. Do not rush the time necessary for the detection systems to identify agent(s), concentrations, or dose rates. For radiation instruments, use plastic baggies to prevent contamination of probes, which invalidates readings.

The Incident Commander will determine time of exposure and notify when to withdraw. Rule of thumb: if reading is 0.1 mGy (10 mrad)/hr or less, entry is permissible. If reading is 0.1 Gy (10 rad)/hr, wait for further guidance. Current NCRP guidelines for lifesaving procedures are 0.5 Sv or higher; military limit is 1.25 Sv. EPA permissible dose limit for lifesaving procedures is 0.25 Sv.

Priorities in a radiation-contaminated environment are, in order, evacuation, decontamination, and treatment. ALWAYS TREAT LIFE-SAVING EMERGENCIES FIRST, prior to evacuation or decontamination.

Initially set up an exclusion zone; an operations zone; and an outer perimeter. If contamination is suspected, set up hot, warm, and cold zones. Regard wind and terrain features, including water runoff from the decon zones. Restrict personnel movement between zones as appropriate. Encourage ambulatory patients to self-rescue to warm zone to undergo decontamination if possible.

Many patients with minimal or no injuries will leave the scene, unwittingly carrying contamination on their skin or clothing. Have media announcements advise these people to bag their clothes in plastic bags, place bags outdoors (NOT in public trash receptacles), and wash hair and body thoroughly with soap and water. Advise on where to report for evaluation, and what symptoms to look for. Record time spent by patients and first responders in radiation areas, along with dose rates.

The basic principle of all medical treatment involving cesium-contaminated patients is that life-saving emergency treatment takes priority over decontamination. It is extremely unlikely that the patient will have enough ^{137}Cs in wounds, skin, or internally to constitute an acute risk to himself or the medical staff. Cesium that is incorporated through wounds, ingestion, or inhalation may be removed with a recently approved drug, Prussian blue. This will require one or two 500 mg capsules to be taken three or four times a day for several weeks. Urinary samples and whole body counters can be used to ascertain progress in removal of contamination.

Except for prolonged exposure to a large hidden ^{137}Cs source, the likelihood of receiving a dose of life-threatening radiation from a terrorist incident involving radioactive cesium is remote. There is a risk of cancer from radiation exposure, which is proportional to the dose received. A rough estimate is a 5% increase in the risk of dying of cancer per Sievert (100 rem) of dose received added to the general U.S. population risk of 22-25%. Both of these numbers vary depending upon gender, age at time of exposure, certain genetic illnesses and predispositions, and other factors. The current accepted theory upon which all radiation risk estimates are based is the linear no threshold model; that is, any additional radiation exposure added to the normal background radiation from cosmic radiation, terrestrial gamma radiation, radon, and even food and water increases the risk of developing cancer in a dose-dependent linear fashion. However, there has never been an epidemiologic study demonstrating a statistically significant increased cancer risk for adults receiving doses of 0.05 Sv or less above normal background.

Summary

The "good news" is that, of the four types of CBRN incidents, an RDD will create the least number of casualties. So far one has never been used, though the possibility is quite real because of the potential panic, economic impact, logistical response in dealing with large numbers of persons who will turn out not to require treatment, and psychological damage caused by realistic, though very small, increased risks of cancer plus other fears. Cesium, because of its long half life, relatively energetic gamma radiation, persistence in the environment, and availability, is a likely choice for an RDD. Fortunately the high energy gamma would make an RDD containing dangerous quantities of cesium relatively easy to detect even from a distance. The key is a high index of suspicion and a survey instrument(s). Medically, it is highly unlikely that acute radiation syndrome or other serious medical emergencies (outside of trauma and burns from the explosives themselves) would occur in the casualties. Therefore first responders and receiving personnel should give first priority to stabilization and treatment of life-threatening injuries, followed by evacuation and decontamination.

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Responders should beware of secondary devices, and turn off pagers and cell phones at the scene.

Do not sit or lean on benches, rails, or other surfaces that may collect contaminants.

Do not eat, drink, or smoke in contaminated areas; only exception is bottled or canteen water through mask portals, to prevent heat stress.

There are no protective medicines against external exposure to cesium.

The Rebirth of the Nuclear Weapons Complex

LTC Richard N. Yaw
Defense Threat Reduction Agency

The United States Nuclear Weapons Complex (NWC) has undergone dramatic change over the last 15 years. In response to changes in the global security environment, US nuclear forces have seen dramatic drawdowns, with congruous changes in the infrastructure existing both in Department of Defense (DoD) and Department of Energy (DOE) to support the nuclear stockpile. The NWC has been downsized significantly to save money and eliminate unneeded capacity while maintaining capabilities mandated by national security, and instituting scientific capabilities needed to ensure stockpile confidence without nuclear testing. Though remarkable progress has been made toward attaining the complex that the US requires to ensure future nuclear security, the National Nuclear Security Agency (NNSA) is standing at a critical juncture. Where necessary, new buildings have been constructed at existing facilities to add new stockpile stewardship capabilities or to replace worn-out production plants. Other than those exceptions, the NWC has collapsed onto itself to the point where it can be consolidated no further without significant loss of capability. At current funding levels, increasing the efficiency of the current system is the only option.

If the nation's nuclear stockpile could be put on a shelf and forgotten until it was needed, today's complex would be fine. But the extreme tolerances to which nuclear weapons are built, and the limits on our understanding of nuclear weapons physics, dictate that they get a lot of "care and feeding". As a result, requirements are growing for programs directed at stockpile life extension. The more we learn about the stockpile the more we need to invest in learning more. Construction costs related to stockpile stewardship tools are a growing burden. Security and maintenance costs of the (still fairly large) existing complex are growing. At the same time, the annual NNSA budget stays constant. As a result of these factors, the budget required to maintain the NWC at the status quo and the requirement for responsive stockpile support are at odds. The complex needs to be further reduced in size and cost, but increased in efficiency, to meet the requirements imposed by the stockpile of today and the future. However, there are forces that resist this change. In order to significantly reduce the size of the NWC, facilities need to close and others need to modernize or absorb capabilities. That requires a significant capitol investment. Members of the Congress and Senate are loath to discuss losing NWC assets in their districts. The federal government is hesitant to "pull the plug" on relatively new construction in order to re-build it somewhere else. Some tough decisions need to be made, and soon, in order to move the NNSA infrastructure toward the responsive capability that our nation requires.

The Historical Context

Since the beginning of the Manhattan Project in World War II, the NWC has been in a constant state of change. What would eventually become the NWC started small. From its humble beginnings as the "Advisory Committee on Uranium" in late 1939, it slowly grew through the formation of the Manhattan Engineering District in the summer of 1942. Over the years following the war, the complex increased in budget and size as technology changed, theory expanded, and the size of the nation's nuclear arsenal literally exploded in response to the threat posed by the Soviet Union during the cold war.

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After the Soviet Union detonated its first atomic weapon on September 29, 1949, the US investment in its nuclear complex increased dramatically. Over the 6-year period from 1947 to 1953, the number of bombs in the US arsenal went from 13 weap-

ons to 1169, almost a 100-fold increase. This growth in the stockpile size and the NWC budget would continue until the end of the Cold War. During the same period, the complex also grew to keep pace with increased stockpile size and production demands. While the complex consisted of 9 facilities (design labs, nuclear and non-nuclear materials production plants, parts fabrication plants, and testing grounds) in 1947, the NWC had grown to its peak of 22 facilities by 1958.

In the period between 1958 and 1989, some new facilities were constructed and others were closed due to improvements in technology, efficiencies in use of materials, environmental and safety reasons, or the signing of the Limited Test Ban Treaty in 1961. By 1989 there were 12 major NWC facilities in operation. After the signing of the series of nuclear forces treaties and initiatives beginning with the Strategic Arms Limitation Treaty and the Strategic Arms Reduction Treaty I, followed by the collapse of the Soviet Union, the size of the nuclear stockpile has been steadily decreasing. In 1994, because of reduced production demands, decreasing budget, and under pressure to close aging, unsafe facilities, DOE undertook a reconfiguration of the non-nuclear portion of its complex. As a result, the NWC was reduced to its current configuration of eight facilities (Figure 1).

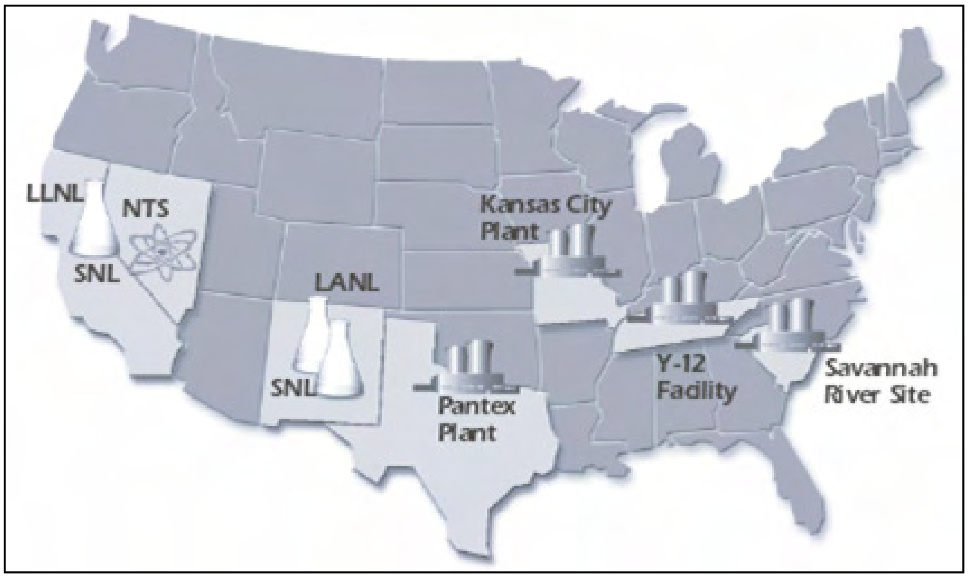

Figure 1. The Current US Nuclear Weapons Complex Consists of Eight Facilities (The 2 SNL sites in NM And CA are Counted Together).[1]

An examination of the budget for maintaining the nuclear arsenal is instructive. The NNSA, which has the responsibility for overseeing the nation's nuclear weapons complex, has seen a roughly constant budget over the last decade in spite of the trend toward a smaller stockpile, whereas one might expect there to be a fairly linear relationship between the two variables. The reasons for the non-linear relationship between stockpile size and budget can be debated, but in general can be attributed to the high cost of building and maintaining the scientific tools and research base related to the Science-Based Stockpile Stewardship Program (SSSP) instituted in the 1990's to assure the safety, security, and reliability or the nuclear stockpile in lieu of underground testing.

Why does the NWC, which neither designs nor produces weapons, and does not conduct nuclear tests, need to be so large? The answer to that question is four-fold. First, the complex must be prepared, equipped, and trained to resume weapon production if deemed necessary by the national leadership. Second, safety and reliability considerations demand that a rigorous program of component testing be executed. Some of this testing program consumes weapon parts, which must be manufactured and replaced. Third, some weapon components have a finite shelf-life, so a continuous manufacturing and replacement parts pipeline is required. Fourth, for various reasons which include safety, security, and lack of commercial sources, some weapon materials can only be manufactured by a dedicated production facility. As a result, the historical legacy which determined the locations of the current eight facilities, combined with the large amounts of money recently spent to build the needed SSSP tools, have frozen us into a complex that is too large and unwieldy to allow for mission accomplishment on time and under budget.

Despite having a weapons activity budget as high as it was at the peak of the Cold War era, NNSA is struggling to meet its obligations for running the NWC today. This is the case even though, in terms of the number of facilities it controls, the complex has been reduced in size almost to the point where it was at its beginning in 1947, and is neither producing nor designing any new weapons. Clearly, something is wrong. The time has come for a paradigm shift in the structure and functioning of the NWC. In spite of annual budget cuts and increasing Congressional pressure to reduce its spending even further, the NWC continues to find itself locked into the eight legacy facilities, when perhaps one or two modern, efficient, design and fabrication plants, combined with judicious use of existing facilities may do the job for much less money. It can no longer afford to operate in the current fashion. The solution to the NWC's conundrum may well be reinvention of the complex.

The Reborn Complex

The idea of a new, leaner, NWC isn't a new one. In fact, even the NNSA has been toying with the idea. In January 2005, the Secretary of Energy, in response to Congressional urging, tasked the Secretary of Energy Advisory Board (SEAB) to form a Nuclear Weapons Complex Infrastructure Task Force. The Task Force, composed of a distinguished panel of independent experts, was tasked to conduct

"… a systematic review of requirements for the weapons complex over the next twenty-five years … Assess the implications of the President's decisions on the size and composition of the stockpile … and the personnel, facilities, and budgetary resources required to support the smaller stockpile. " [2]

In October 2005, the so-called "Overskei Panel" turned in its final report to the Energy Secretary. Among its many findings, the report stated that the NWC had no master plan, redundant facilities, excessive competition between facilities, and increasing vulnerability to terrorist attack amid increasing security costs. The report concluded that the "status quo is neither technically credible nor financially sustainable." [3] Among its chief recommendations, the panel created a master plan that restructured the entire nuclear complex, urging NNSA to establish a Consolidated Nuclear Production Center (CNPC), to produce all the components in the "nuclear explosive package", closing at least two current facilities altogether and dramatically reducing the size of the remaining sites. Additionally, the panel recommended pursuing new family of weapon designs that would enable efficiencies in the complex along with greater safety, security, and reliability.

If the complex needs to be reborn, what does this CNPC need to look like? What capabilities does it have to have? What are the production requirements? What should the footprint be? These are important questions to answer. Some would argue that the answer depends on the size of the nuclear stockpile. The problem with that argument is the extremely long lead-time necessary to design and build a "new" complex. It could take 10-15 years to complete construction on such a facility. Using stockpile size as the basis for sizing the CNPC requires knowing the size of the stockpile in the year 2016 and beyond. That's a very tricky thing to predict. Usually one encounters heated debate over what the nuclear stockpile will look like next year, much less 10 years from now. Looking to such a contentious number for the basis of sizing a complex is a recipe for certain inaction. What must be done is to find the right size for the complex by focusing on the capabilities that it must have, while preserving the flexibility to surge capacity or expand if needed.

Wanting to know the future size of the stockpile is a good idea. As one might expect, the NNSA generally looks to their customer, the DoD, to provide guidance on the matter. In the 2002 Nuclear Posture Review (NPR), the SECDEF gives definitive guidance on the future of our strategic forces and nuclear stockpile:

" … [the NPR] shifts planning for America's strategic forces from the threat-based approach of the Cold War to a capabilities-based approach. … should provide, over the coming decades, a credible deterrent at the lowest level of nuclear weapons consistent with U.S. and allied security." [4]

While not giving any numbers, clearly this excerpt demonstrates that the size of the stockpile is headed in one direction … downward. The precise end-state of the future, smaller stockpile is a matter for debate, and it is debated often and sometimes heatedly. The point here is that NNSA cannot afford to put off a decision till the debate is resolved. By that time it's too late to act. Plants will have shut their doors, experts will have retired, and young workers will be uninterested and untrained. The design of the CNPC has to go forward with some assumptions made about the general trend of the stockpile, bounded by numbers that make sense from an engineering point of view. What are the possible scenarios for stockpile numbers, and what difference do they make in the design parameters (i.e., capacity requirements) for the CNPC? It is not within the scope of this article to do that analysis, but it most certainly needs to be done. Somewhere in the analysis, break points and critical design objectives that identify the correct sizing for the complex can be identified.

If the complex needs to be reborn, what does this CNPC need to look like? What capabilities does it have to have? What are the production requirements? What should the footprint be? These are important questions to answer. Some would argue that the answer depends on the size of the nuclear stockpile.

As an example of what might be found, say for argument's sake that the stockpile has currently been drawn down to the point where there are 10,000 warheads. Further, assume there are credible signs that, in the future, we will eventually (in 2030 time-frame, say) get down to 5,000, or maybe 1,000 warheads. If there are no DoD requirements indicating to the contrary, the NWC would immediately want to start orienting its infrastructure to support the 1,000 warhead stockpile. During the transition period, of course, current systems would need to be sustained until their ultimate retirements. There are a number of options that NNSA can pursue in "downsizing" the NWC to fit this future requirement. It can close several current operating plants and re-open a new CNPC at another site (Los Alamos, Kirtland AFB, or at the National Test Site in NV, for instance). There are existing facilities, both aboveground and underground at those sites that might make

excellent locations for secure production and storage. It might also be possible to collocate some production facilities at underground former nuclear facilities on current DoD bases, thereby leveraging the security advantages offered by such an arrangement. These are just a few of the possibilities that need to be explored.

What's the Payoff?

The current budget supporting the NWC is about $6 billion. Every year, the need for new facilities is voiced by the complex. Every year, costs increase for current programs. The critical SSSP "tools" are experiencing severe cost overruns. The budget, however, does not and most likely will not be increased by Congress. To the contrary, the fiscal demands placed on the federal government by the Global War on Terror are forcing Congress to look everywhere for ways to cut spending, so NNSA is under constant pressure to reduce its budget. There is no excess money to put into ideas like building more efficient, co-located facilities. Forget about serious weapon research programs, even for noble reasons like improving the safety, security, and reliability of the stockpile, not to mention the annual cost of maintaining it. The payoff on increased investment in the NWC will be the ability to step forward, to move forever and finally out of the Cold War period, leaving legacy sites behind and seeing the phoenix rise from the ashes of the old complex.

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ENDNOTES

[1] Nuclear Weapons Stockpile Management Handbook, Deputy Assistant to the Secretary of Defense (Nuclear Matters), June 2003, 102.

[2] U.S. Congress. House. Committee on Appropriations. Energy and Water Development Appropriations Bill, 2005, H.Rept. 108-554, to accompany H.R. 4614, 108th Congress, 2nd Session, 2004, p. 111.

[3] Letter from Dr. David O. Overskei, Chairman, SEAB Nuclear Weapons Complex Infrastructure Task Force, to M. Peter McPherson, Chairman, Secretary of Energy Advisory Board, October 4, 2005, 1 p., and letter from Peter McPherson, Chairman, Secretary of Energy Advisory Board, to The Honorable Samuel W. Bodman, Secretary of Energy, October 4, 2005, 1 p.

[4] Although the NPR is classified, some portions are not, and excerpts are widely available. The quotation was extracted from the website of Globalsecurity.org, Nuclear Posture Review [Excerpts], Submitted to Congress on 31 December 2001, http://www.globalsecurity.org/wmd/library/policy/dod/npr.htm,
8 January 2002

Manufacture and Testing of an Activation Foil Package for Use in Activation Foil Integrated Detection System (AFIDS)

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Both parties in the 2004 United States (US) Presidential campaign debates indicated that the most dangerous threat to the US was a domestic nuclear event. Although no one likes to dwell on this scenario, we must be prepared to deal with it. Specific information about the device involved has not only political implications but is important for relief operations and public safety.

A critical aspect of a nuclear detonation on US soil will be the attribution of the attack to a specific country or group. A nuclear event requires analysis to determine data such as weapon type and characteristics for use in Domestic Nuclear Event Attribution (DNEA). Much of this information can be gained from the prompt neutron spectrum of the weapon. Materials near the detonation will be activated by the prompt neutrons and information about the neutron spectrum can be gained from the analysis of these activated materials.

One difficulty with using typical activated materials from near the detonation site is that the exact composition of the materials is unknown. The proposed Activation Foil Integrated Detection System (AFIDS) is a passive radiation detection system consisting of packages containing foils of known composition. These foil packages would be placed at regular intervals throughout a potential target area. In the event of a nuclear explosion, the foils located near the detonation, become activated by prompt neutrons from the nuclear detonation. Since the foils are chosen to activate with neutrons at certain energy thresholds and the reaction cross-sections are well known, the activity of the foils collected after a nuclear detonation provide fluence and energy information about the neutron spectrum.

At a certain point, the neutron flux can be calculated by computer using a known neutron flux from a known source. In the case of an unknown source, if enough information is available from threshold activation measurements, it should be possible to unfold the neutron source spectrum using adjoint calculations. This method has been proven in and out of the laboratory in limited cases. Oak Ridge National Laboratory (ORNL) has developed a computer code to compare an unknown neutron spectrum to a database of known nuclear weapon spectra and rank-order the best fit. Prior to any detonation, air-over-ground adjoint radiation transport calculations are performed for each type of known foil and the results stored. After a detonation, as many foils as possible are recovered and then measured to determine saturation activity. Once the detonation location is known, the calculated saturated activity for each foil is obtained by folding all the known weapon leakage spectra with the precalculated adjoint fluences at the detonation location. The calculated and measured activities can now be compared and the most probable weapon spectra determined by least squares fitting. The comparison rank-orders the closest matches to known spectra and eliminates weapons and types that do not match. The features of the most closely matched spectra indicate types (e.g. uranium vice plutonium) and help to validate results from other methods such as fractionation analysis.[1]

Testing the method can be accomplished by generating data, introducing noise and checking results; but true validation requires testing independent data. To provide this data, foil packages were designed with the aid of Standardized Computer Analyses for Licensing Evaluation (SCALE) software and activation experiments planned to replicate a nuclear event as closely as possible.

For the purposes of design, the simulated point source was monoenergetic at 14 MeV (upper energy limit of bomb neutrons) and yielded 10^{24} neutrons, approximately the equivalent of a five-kiloton weapon. The duration of neutron production from a nuclear device is on the order of microseconds while the half-lives of the decay elements are on the order of hours or longer. Thus, the decay of the radionuclides during activation was assumed negligible and ignored when calculating activation.

The foils used are subject to physical and practical constraints. The atomic content of the foils has to be known so ORNL can do precalculations and time is not spent after retrieval determining the composition of the foils. The reactions of interest have to cover all parts of the neutron spectrum to include thermal, epithermal, and fast neutrons. The cross-section of the reaction of inter-

Table 1. Determining Foil Size from Projected Activity.

	($\sigma\phi$) SCALE [n/s]	radius [cm]	length [cm]	mass [mg]	Initial A [Bq]	T½ [days]	A at +4 days [Bq]	Min. A [Bq]
Al								
500 m	6.26×10^{-13}	0.05	1.00	21.20	3815.97	0.62	44.56	10.0
700 m	2.07×10^{-13}	0.05	1.00	21.20	1259.02	0.62	14.70	10.0
800 m	7.64×10^{-14}	0.05	1.00	21.20	465.41	0.62	5.44	10.0
Au								
500 m	9.46×10^{-12}	0.05	0.30	45.47	1707.56	6.18	1090.37	12.4
1100 m	1.85×10^{-13}	0.05	0.30	45.47	33.33	6.18	21.28	12.4
1200 m	6.22×10^{-14}	0.05	0.30	45.47	11.22	6.18	7.17	12.4
Co								
500 m	6.24×10^{-11}	0.05	1.00	69.90	185.90	1923.92	185.63	10.0
1100 m	3.80×10^{-12}	0.05	1.00	69.90	11.33	1923.92	11.31	10.0
1200 m	8.38×10^{-13}	0.05	1.00	69.90	2.50	1923.92	2.49	10.0
In								
100 m	1.22×10^{-9}	0.05	1.00	57.41	1.58×10^{7}	0.19	5.73	23.0
500 m	2.49×10^{-11}	0.05	1.00	57.41	3.22×10^{6}	0.19	0.12	23.0
La								
500 m	1.15×10^{-11}	0.05	0.50	24.13	5747.28	1.68	1101.60	10.5
1600 m	2.72×10^{-13}	0.05	0.50	24.13	136.26	1.68	26.12	10.5
1700 m	1.32×10^{-14}	0.05	0.50	24.13	6.62	1.68	1.27	10.5
Mn 80%								
500 m	2.71×10^{-12}	0.05	1.50	68.80	52.60	312.10	52.14	10.0
700 m	5.23×10^{-13}	0.05	1.50	68.80	10.14	312.10	10.05	10.0
Ta								
500 m	3.83×10^{-10}	0.02	0.50	9.44	844.82	114.43	824.60	28.7
1000 m	6.65×10^{-11}	0.02	0.50	9.44	146.42	114.43	142.91	28.7
1100 m	1.33×10^{-11}	0.02	0.50	9.44	29.33	114.43	28.63	28.7
V								
500 m	6.23×10^{-14}	0.05	1.00	47.99	155.61	1.82	33.95	10.0
600 m	3.38×10^{-14}	0.05	1.00	47.99	84.41	1.82	18.42	10.0
700 m	1.60×10^{-14}	0.05	1.00	47.99	40.00	1.82	8.73	10.0
Ni	cross-section for (n,p)							
500 m	3.67×10^{-12}	0.05	1.00	69.92	298.12	70.88	286.68	10.1
1000 m	1.57×10^{-13}	0.05	1.00	69.92	12.74	70.88	12.25	10.1
1100 m	9.82×10^{-14}	0.05	1.00	69.92	7.97	70.88	7.67	10.1
Cu	cross-section for (n,α)							
250 m	1.61×10^{-12}	0.05	2.00	140.74	8.93	1923.92	8.92	10.0
500 m	1.51×10^{-13}	0.05	2.00	140.74	0.84	1923.92	0.84	10.0

est has to be well documented to allow ORNL to perform calculations. To prevent self-absorption, the mean free path of the resulting gamma must be greater than the material thickness through which the gammas will be measured. For the purposes of packaging, the choice of foils was restricted to ones that are available in wire form.

Another limitation on the foils was that activity had to be measurable four days after activation. Simulations were used to determine the size of foil needed to obtain this level of activity. The simulations were run on each type of foil at 500 m from the source and the results were used to calculate the activity (A) four days after the activation. The sizes of the wires were adjusted to attain an activity between the minimum for the particular wire and 1000 Becquerel (Bq). The significant results for the wires chosen are presented in Table 1.

The activity of indium after four days was below the minimum of 23 Bq due to the short half-life but could still be useful if collected early enough. The foil length was limited to 3 mm to keep it upright in the glass tubes used to package the foils. Table 1 also contains the distance from the source the foil was expected to perform. For example, vanadium should perform as designed to between 600 and 700 meters as it activated to 18.42 Bq at 600 meters but only 8.73 Bq at 700 meters.

Reactions of interest from neutron activation were limited to ones that produce gamma rays during decay to facilitate counting. Detectors used to measure the gamma activity of the foils should have resolution better than 10% full width at half maximum (FWHM) and 1% absolute efficiency at 1 MeV. For design purposes, 1% absolute efficiency was assumed and 0.1 counts per second as the lower limit of counting based on counting with a High Purity Germanium (HPGe) detector for two hours. Foils were assumed to be located 500 meters from a five-kiloton nuclear weapon detonation and the activity measured four days after the nuclear event for design purposes. Since the lower limit of counting is 0.1 counts per second and assuming 1% absolute efficiency, the minimum activity of the foil four days after activation is dependent upon the decay percentage and the branching ratio of the individual radionuclide. The maximum activity of the foil four days after activation was limited to 1000 counts per second to minimize pile-up and dead time and to allow the same geometry for all foil counting. Higher activities can be counted by placing the foil farther from the detector but the system must then be recalibrated.

A nuclear detonation and a conventional explosion are similar in that a large amount of energy is released within a limited space and time. This energy release drives the temperature and pressure up converting nearby materials to hot, pressurized gasses. These gasses expand quickly and produce a shock or blast wave. A nuclear detonation differs from a conventional explosion in that much more energy is released in a shorter time with less mass. Much higher temperatures are achieved and more energy is emitted as heat and light (thermal radiation). For example, a foil package 500 meters from a ground burst of a 5 kT device will experience an overpressure of 8 psi and 50 cal/cm^2 of thermal radiation.[2]

The foil packages are also subject to constraints other than just surviving the effects of the nuclear detonation. Since the exact location of the blast is unknown, the foil packages cannot be oriented towards the blast and must be designed to capture fast and epithermal neutrons from any direction. Direction is not as important for thermal neutrons because thermal neutrons reach equilibrium in velocity and

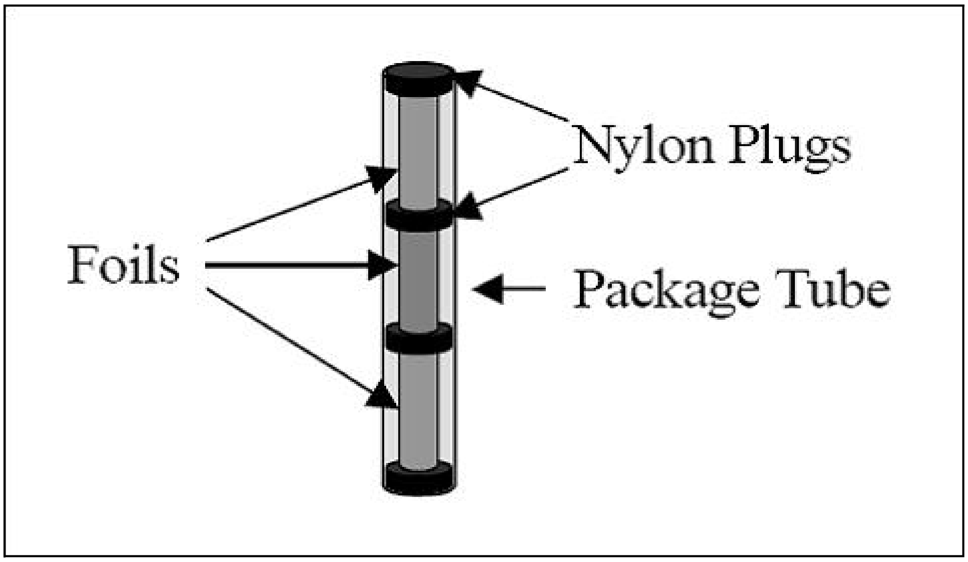

Figure 1. Foil Package.

will backscatter into the foils. The foil packages should not present a hazard to the general population or the environment. Self-shielding within the packaging of the foils needs to be minimized so each foil gets maximum exposure to the prompt neutrons. The cost per foil package needs to be low since a significant number of foil packages are needed to cover potential targets and low cost reduces pilfering. A limit of five dollars was assumed.

The geometry shown in Figure 1 meets the 360-degree coverage limitation while keeping the foils from shielding themselves or each other. Initial planning has the foil packages placed on high structures such as building tops and cell phone towers to maximize exposure.

The packaging should also not shield the foils or it may change the spectrum for activation. Silicon carbide, with a high melting point, a high modulus of rupture and a low absorption cross-section[3] and was determined to make an ideal packaging material. 50 cal/cm^2 of thermal radiation translates to an increase of 900° C in silicon carbide assuming the radiation is absorbed in the first millimeter of material, well within the ability of SiC to protect the foils.

Since actual nuclear weapon testing is not available for evaluating the foil packages, alternate neutron sources were used. A good source for replicating a nuclear weapon should yield as many fast neutrons as possible and be capable of operating in a controlled outdoor setting, which would be ideal to represent the air-over-ground transport with the associated ground and sky shine.

In the case where a source cannot be taken outside, the distance and scattering mechanisms must be simulated or engineered. This could be accomplished by placing a volume of liquid between the source and the foil packets. The theory behind this is that the liquid is much denser than air so with the correct geometry the number of molecules encountered by the neutrons passing through the liquid would be equivalent to the number of molecules encountered by the neutrons passing through air over a much greater distance. For example, liquid N_2O has 6.3 x 10^{22} atoms in a cm^3 and air, modeled as 78% nitrogen and 22% oxygen with a density of 1.1 mg/cm^3, has 4.6 x 10^{19} atoms per cm^3. This gives a ratio of 1371 or 1 cm of liquid N_2O should appear as 13.71 meters of air. Using liquid to replicate air in depth also has the added advantage of having more neutrons available at the experiment if the same source is used. The flux from an isotropic source decreases by the square of the distance from the source. Using a volume of liquid to replicate a volume of air significantly reduces the distance-squared factor because of the smaller distance traveled by the neutron. Thus, a much higher flux can be attained while still accounting for scattering through a large distance of air.

The concept of using compressed gasses or liquids to represent distances of air was investigated using SCALE to simulate neutron transport through 7 cm of liquid N_2O. The simulation was repeated by replacing the N_2O with liquid air modeled the same as the dry air but with density of 1.53 g/cm^3. To obtain transport through air data, the simulation was repeated replacing the N_2O with the modeled air and placing point detectors between 93 and 175 meters.

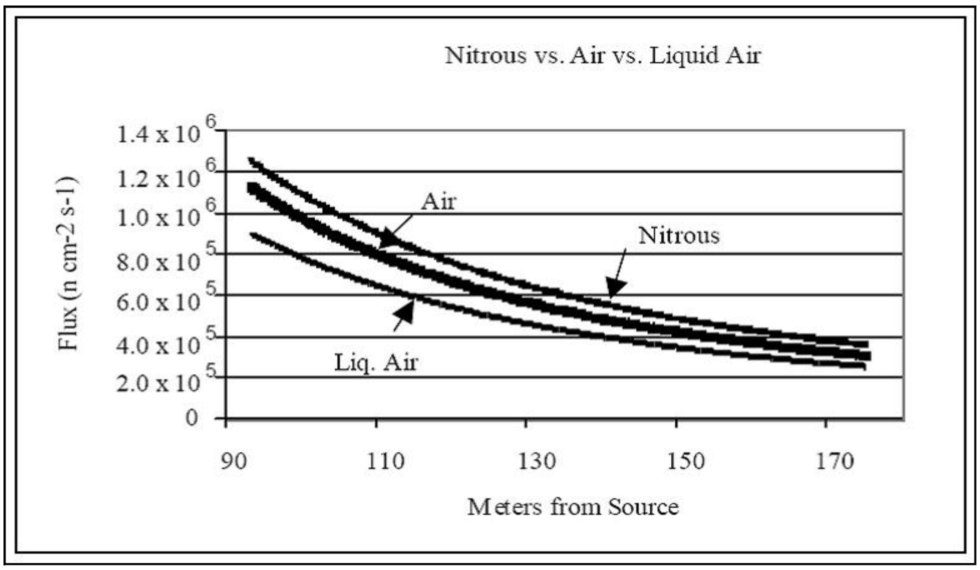

Figure 2. Comparison of SCALE Simulations for N_2O, Air and Liquid Air.

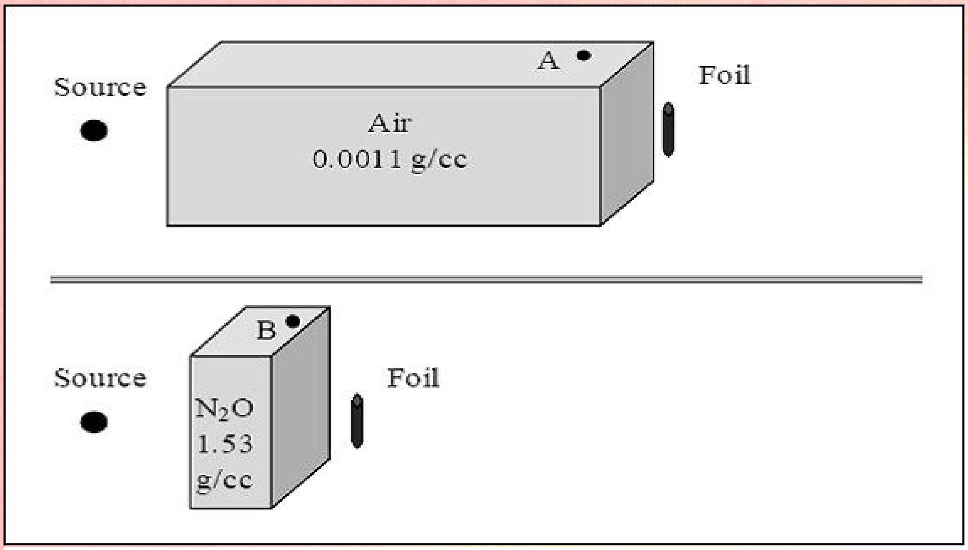

Figure 3. N_2O and Air "Equivalency".

Using the number of atoms per unit volume, 7 cm of N_2O should be equivalent to 96 meters of air. The results of the simulations, graphed in Figure 2 with the dispersion factor applied to the N_2O and liquid air results, lead us to believe that it is not quite that simple. If the 7 cm of N_2O was equivalent to 96 meters of air for neutron transport, the results should have crossed at 96 meters on the graph and the liquid air should have followed the normal air exactly.

Figure 2. (page 24.) Comparison of SCALE simulations for N_2O, air and liquid air.

Using N_2O or liquid air to simulate large volumes of air is a very attractive proposition; however, the concept is not as accurate as first thought. A possible explanation is that the angle of approach between neutrons and nucleons is different at different distances from the source. This would change the probability of interaction and add an unknown factor to the solution. For example, point A in air in Figure 3 has a corresponding point B in N_2O. Point A would have a different probability of interacting with a neutron leaving the source at a specific angle than would Point B. The problem of different angles of interaction at depth needs to be resolved.

The only true validation of the methodology used by ORNL and the foil packages is to conduct an outside test using a neutron source that closely resembles a nuclear detonation. An outside test would allow air over ground transport of neutrons, complete and measurable activation of foils, ability to conduct spectroscopy of the foils and an independent and valid set of data to transfer to ORNL for validation. Until an outside test is conducted, AFIDS can be partially validated by engineered tests replicating reality, such as using nitrous oxide to replicate large volumes of air, or by simulation which uses code to validate code. Neither option is ideal, and it is beyond the scope of this article to discuss the validity of either method.

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ENDNOTES

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Development of Chemical Warfare Agent (CWA) Simulants for Point Detectors

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Certain lessons can only be learned by testing equipment in the field. Even as our testing technology approaches our capabilities to accurately mimic field conditions, testing technology has not yet supplanted the role of troops interfacing with equipment. The unpredictability of actual field testing has to be addressed before any piece of equipment can be fielded. Adequate operational testing (OT) and subsequent equipment improvement makes the difference between useful force enhancement items or the proverbial doorstop. Fortunately, most equipment does not make decisions without human intervention and can now be tested in the field under real or realistic threat conditions. These advantages are not available for chemical warfare agent (CWA) point detectors, since President Nixon's ban on open air testing in 1969. Therefore, these detectors require a greater reliance on developmental testing (DT) to measure performance. Although this would seem a hindrance, by using wise strategy in simulant selection, CWA can be replaced by non-toxic, environmentally-acceptable compounds for operational field testing use. These compounds produce clouds characteristic of military or terrorist dissemination methods.

If we think operationally about CWAs and their physical properties in the field, the most desired application for CWAs would produce a vapor, linger (or remain semi-persistent), and not rapidly degrade. The same can be expected from a good simulant, and many classes of compounds can meet these battle criteria. Traditional compounds such as methyl salycylate (MeS), dimethyl methyl phosphonate (DMMP), and triethyl phosphate (TEP) have been used for years and still may be adequate simulants for certain tests. Other simulant candidates include organophosphates, food additives, and fragrances. The latter class of compounds has been the focus of the latest simulant selection. Some of the potential simulants considered included: benzyl butyrate, which smells like jasmine; anisyl acetate, which smells like lilac; and 3,7 dimethyl-1-octanol, which smells like waxy rose. The results of the currently tested simulants are very promising and provide an expedient method for challenging detectors in the field and improving the safety of the soldier during OT. Though the list of simulant fragrances and corresponding results cannot be printed here, they are available from the West Desert Test Center (WDTC) at U.S. Army Dugway Proving Ground (DPG).

Simulants are normally identified early in detector testing as a part of research and development; however, for systems that are bought as commercial off-the-shelf items, simulants are identified during the production qualification testing. The selection method used by DPG for choosing point detector simulants for current customers involves a number of factors:

1. Technology of the detector.
2. Vapor pressure of the simulant compared to that of the CWA.
3. Human safety factors.
4. Effective dissemination.
5. Simulant cost.
6. Referee systems that will be employed during field testing and their response to the simulant.
7. Environmental acceptability for field release.

Ideally, adequate simulants would be programmed into the detectors before testing. The better a simulant can be effectively used for detection, protection, and decontamination testing, the more that simulant will be chemically similar to CWA (including toxicity). However, the set of simulants selected may not be what a user needs for field testing. The above factors can be used to make a mathematically unbiased decision by weighting those most important for the field testing event. It must be stated that these factors can only be employed for chemical point detectors and are not designed to select simulants for decontamination or protective equipment testing.

Detector Technology

Detector technology becomes important in determining which characteristics the simulant shares with agent. The key to selecting a simulant for detector test use is to select a

non-CWA compound that produces a signature in the detector that is indistinguishable from the CWA or on which the detector can be trained on a non-interferent basis with CWA. For example, a chemical simply has to ionize to cause an alarm in a photoionization detector (PID). However, no simulant has been found that will match the agent signature for a gas chromatograph mass spectrometer (GC-MS).

There are a wide range of point detector technologies currently being used for CWA detection. A quick general ranking of common detectors from most elegant to least would be GC-MS (used in laboratory analysis), GC (used in safety air monitoring and laboratory analysis), surface acoustic wave detectors (SAW, used in development for field use), infrared (IR, rare but available for field point detectors), ion mobility spectrometer (IMS, most common fielded point detector), flame photometric detector (FPD, French fielded point detector), and photoionization detector (PID, commercially available point detector).

Our current efforts have focused on finding simulants for IMS detectors and serve as an example to be used when selecting other technologies. Selection was greatly aided by understanding the physics of producing the signature that challenges the detector.[1] For IMS, a CWA molecule is ionized by a weak radioactive source, or corona discharge source, and inserted into an electric field. Ions move in an electric field according to mass and ion charge. The time it takes the CWA ion to be inserted into the field and drift to the sensor will determine CWA identification. All of this can be described by a mathematical equation used to calculate a list of potential simulants that could produce a drift time identical to CWA challenges.

Non-IMS CWA detectors will also respond to molecules with similar properties present in the CWA. As an example, TEP and DMMP produce a response similar to nerve agent from an FPD. TEP and DMMP have a similar heteroatom (P) to that of the nerve agents tabun (GA), soman (GB), sarin (GD), cyclosarin (GF), and persistent nerve agent (VX). From the combustion of an organophosphorus compound (eg., TEP, DMMP, GA, GB, GD, GF, or VX), a short-lived, radical, intermediate HPO is produced. HPO emits light that is measured by the FPD.

After a simulant has been chosen, an experimental design must be used to produce mathematical performance descriptions (performance curves), which provide a correlation between the CWA and simulant detector response. At a minimum, the performance curves should show how the detector responds to CWA/ simulant over the required concentration temperature and humidity ranges and other critical, technology-specific parameters. No adequate correlation can be made without adequate performance curves, and we expend a lot of effort to get this right.

Relationship of the Vapor Pressures of the Simulant and CWA

Vapor pressure as a function of temperature is another important characteristic to consider in point detector simulant selection. This is because a point detector must be in vapor contamination before detection can occur (unlike standoff detection). Vapor pressure affects the detector's ability to sample (time to alarm), detect (interaction with sensor surface), and off-gas (time to clear). An operational example would be the ability of the detector to detect a low-volatile CWA at lower temperatures where the challenge vapor concentration would be very low, effectively "freezing" the sampling portion of the detector, unless preventative steps were previously taken.

Classic physical relationships can be used to predict and match simulant and CWA vapor pressure curves over a wide range of temperatures. Figure 1 shows an example of two potential simulant vapor pressure curves as a function of 1/T compared to the distilled mustard (HD) vapor pressure.[2] In this example, molecular properties other than molecular weight can determine how close the vapor pressures match. Here, the molecular weight (MW) of n-amyl butyrate (MW = 158) is much closer to HD (MW = 159) than MeS (MW = 152). However, the vapor pressure of MeS is closer to the vapor pressure of HD.

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A variety of models have been developed over the years to predict vapor pressure as a function of temperature. The Clausius-Clapeyron equation is the most common model and will give an accurate prediction of the vapor pressure as a function of temperature over the temperature range of interest (0 to 50^{o}C) for all nerve and blister agents and most simulants. (see Figure 1.)

If the chosen simulant has a vapor pressure that is significantly different from the CWA, two issues must be considered: (1) will the challenge require that all of the simulant be vaporized?; or (2) will the vapor be generated by evaporation from a liquid source?

If the simulant is entirely vaporized (as in stack dissemination during field testing), then the meteorological conditions and referee response needs to be known to determine the challenge. If the vapor comes from a liquid source, such as liquid droplets on surfaces, then the vapor pressure

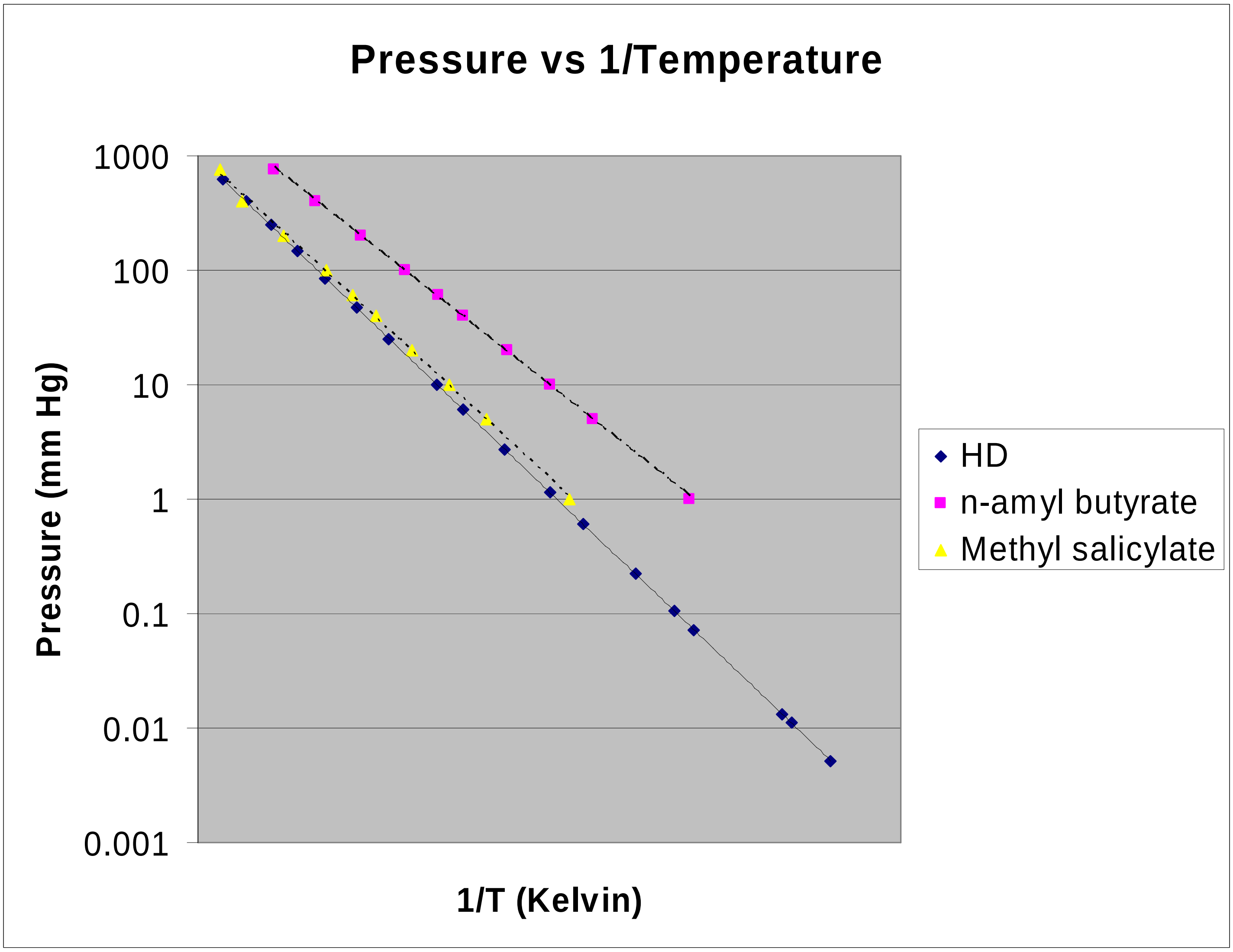

Figure 1. Vapor pressure as a function of 1/T where the temperature, T, is in Kelvin and vapor pressure is in mmHg for HD, MeS, and n-amyl butyrate. It is clear from this graph that MeS more accurately approximates the vapor pressure of HD than does n-amyl butyrate. **Note**: This is the typical plot expected for the Clausius-Clapeyron equation.

becomes a significant issue. The vapor pressure of the simulant and CWA can be determined from the Clausius-Clapeyron equation; then the simulant challenge can be correlated to a CWA concentration at a different temperature and an equivalent challenge determined.

The Safety of the Simulant for Exposure to Personnel

When considering a potential simulant, toxicity must be addressed for human exposure. This will affect the degree of operational realism that can exist in field testing. For example, MeS is approved for human use, and a large quantity can be disseminated around exposed troops not wearing protective gear. The same is not true for other field simulants such as TEP and acetic acid (AA). For these simulants, protective measures must be in place or taken before a challenge can occur. These measures will significantly alter operational realism and tempo.

To determine the likely risk of exposing people to a potentially hazardous simulant, various sources of information should be evaluated, including the Material Safety and Data Sheets (MSDS) and current industrial uses. The MSDS will most likely have toxicity information on the simulant. The data may be for ingestion, inhalation, and/or dermal exposure. Generally, the main exposure risks for personnel in a field test result from either inhalation of fumes and/or dermal exposure to liquid. The MSDS will usually list the lethal dosage for some animals as well as the method of exposure. Safer chemicals generally have higher lethal dosage levels.

If the MSDS does not provide toxicity information, some insight into the simulants' toxicity can be obtained by determining the industrial uses. If any of the industrial uses are as food additives, medications, or personal hygiene products, then the simulant is likely to be relatively nontoxic.

WDTC/DPG possesses a number of currently used simulants, including MeS and TEP. The relative toxicity of the potential simulant should be compared to these two simulants. If the toxicity of the simulant is less than

that of either MeS or TEP, then the simulant will likely be able to have personnel exposed to it when the proper personal protection equipment (PPE) is used.

Simulant Dissemination

At WDTC/DPG, two main types of field dissemination, stack and explosive, are currently used. To determine if a chemical is likely to be disseminated, a comparison of the flash points of the proposed simulant with simulants that are currently disseminated must be done. For example, if the flash point of the potential simulant is higher than 39°C (the flash point of the HD simulant AA), then the simulant could possibly be disseminated with only minor methodology work. The flashpoint comparison must be done to determine that the chemical is less reactive than the most reactive simulant currently used.

If the MSDS does not provide toxicity information, some insight into the simulants' toxicity can be obtained by determining the industrial uses. If any of the industrial uses are as food additives, medications, or personal hygiene products, then the simulant is likely to be relatively nontoxic.

When considering an explosive dissemination, thermally-induced mass losses of CWA or simulant in an explosion need to be evaluated. Again, the simulant's flash point must be considered to avoid producing a "fireball" during explosive releases. The explosive dissemination of CWAs will produce a number of chemical by-products, which must be evaluated to determine how they will affect the point detectors in detecting CWAs. Similar evaluations of the effects on a detector's ability to detect CWA also need to be carried out with simulants and the reactant products.

Simulant Cost Effectiveness

In order to determine whether a potential simulant will be cost effective, it is necessary to consider whether the simulant has commercial applications. Those simulants that have current commercial uses are likely to be procurable in bulk quantities (more than 500 gallons) with reasonable lead times of two months or less. By having commercial uses, it is likely that the production limits of the manufacturer will exceed the current usage levels, and the purchases will not have any effect on the supply of the chemical. Therefore, the price will not be affected by test requirements. If the simulant selected does not have any commercial usage, then a vendor will need to be contracted to produce the simulant. This will likely require a significant amount of development time and funds, as well have unknown health risks and unpredictable costs and lead times. This makes using a simulant without current commercial usages an unacceptable option.

Referee Detector Response to Simulant(s)

Finally, the response of the referee systems to the simulant(s) also must be determined. A desirable referee system will respond to simulants for both test concentrations and environmental conditions. The technology used in a referee system determines if it will respond to the simulant over the required concentration range.

At WDTC/DPG, the two most common referee systems are based on passive IR spectrometry and photoionization. A passive IR system detects chemicals based on the absorption of IR light at various wavelengths. The wavelengths of IR light that are absorbed depend on the functional groups in the simulant. The PID will produce a response to any chemical with an ionization energy less than that of the lamp. Note that standard lamps used in PIDs have energies of 9.80, 10.6 or 11.8 eV. As discussed earlier, the referee detectors need to be tested using a Design of Experiment approach to determine how the referee detectors respond to simulant and environmental factors.

The referee detector does not need to be tested with CWA, or even be able to detect CWA, under any conditions. In fact, requiring the referee detector to respond to CWA may limit the selection of referee equipment employed during field tests and unnecessarily compromise the development of the best test.

Summary

Point detector field testing is complicated by not using CWA(s) in field testing environments with live troops. DT strategies may provide the means of selecting an adequate simulant that can replace actual CWA in the field. However, even with successful selection, proper testing of a CWA and simulant to produce mathematical descriptions of performances is mandatory for quantitative field measurements. Our simulant selection method explored many factors; by using both physics-based prediction and actual test measurements, and focusing on fragrances, WDTC/DPG has successfully created a list of simulants for IMS detectors.

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Geophysical Methods Applied to the Detection of Subsurface Voids: Challenges, Advantages and Limitations

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Throughout history, mankind has gone to great lengths to conceal and protect vital strategic assets. In the Spring 2005 issue of the NBC Report, COL David Fiely notes that the use of underground facilities (UGFs) to conceal Weapons of Mass Destruction (WMD), ballistic missiles, leadership and other activities is expanding. In 2003 alone, there were observations of more than a dozen new military or regime-related UGFs under construction, many within nations with WMD programs.[1]

One of the challenges confronting the Research and Development Community within the Department of Defense is how to effectively utilize and simultaneously improve best-available geophysical technologies to find, characterize and assess (underground) facilities of interest.

Effective utilization of geophysical technologies basically comes down to ensuring that the most appropriate tool available is employed given the target environment, size, shape and depth. There is no 'one size fits all' solution. Improvements to existing technologies are also necessary to support real-time imaging of subsurface targets and to ensure practical depths of investigation are increased significantly without sacrificing spatial resolution. Post-acquisition data enhancement and processing technologies as well as interpretation methodologies must be improved and made more user friendly.

Superior quality data and more efficient assessment capabilities will provide commanders and policymakers a more accurate vision of their battlespace. When facilities of interest, to include associated tunnels and their respective host geology, are accurately mapped and analyzed, it will add to the array of options available to planners. Moreover, accurate knowledge of sites of interest is required to feed increasingly complex models that will ultimately result in a reduction of collateral and environmental damage should military options be considered.

Advantages of Geophysical Technologies:

Geophysics is the science of applying the principles of physics to the investigation of the structure and properties of the earth. Geophysical tools essentially measure parameters that are functions of contrasts in the physical properties of materials beneath the surface of the earth. These measurements help to deduce the nature and distribution of the materials responsible for these contrasts.[2] Most geophysical methods are predicated upon the observation that different materials, such as air, sand and granite have contrasting physical properties. In many instances, these contrasts can be measured, geospatially mapped, and transformed into a geologic model.

In Table 1 (at the end of this article page 37), several conventional geophysical technologies are listed, along with their measured parameters, relevant physical properties, and output models (with and without constraints).[3]

Geophysical technologies have tremendous advantages compared to conventional invasive technologies such as excavating or drilling. These advantages are primarily related to speed and cost. Geophysical data can be acquired much more rapidly and at a fraction of the cost of a comparable trenching or drilling program. However, one significant disadvantage of geophysical technologies is that the output is an interpretation – not necessarily ground truth.

Geophysical technologies have significant limitations apart from the potential for misinterpretation. The most serious limitations are related to: 1) the timeliness of the results and user friendliness of the technology; 2) resolution and depth penetration; and 3) proximity to the study site. The first limitation can probably be solved with effort and capital. The second and third limitations are more serious challenges.

Resolution Versus Depth Penetration

The most serious limitation of geophysical technologies (re: detection of voids) is that resolution decreases as the depth of investigation increases. This is true of all of the surface-based technologies. For illustrative purposes the limitations of wave-based geophysical tools are discussed herein.

In general terms, higher frequency (shorter wavelength) waves provide greater spatial resolution (can image smaller targets) but have relatively

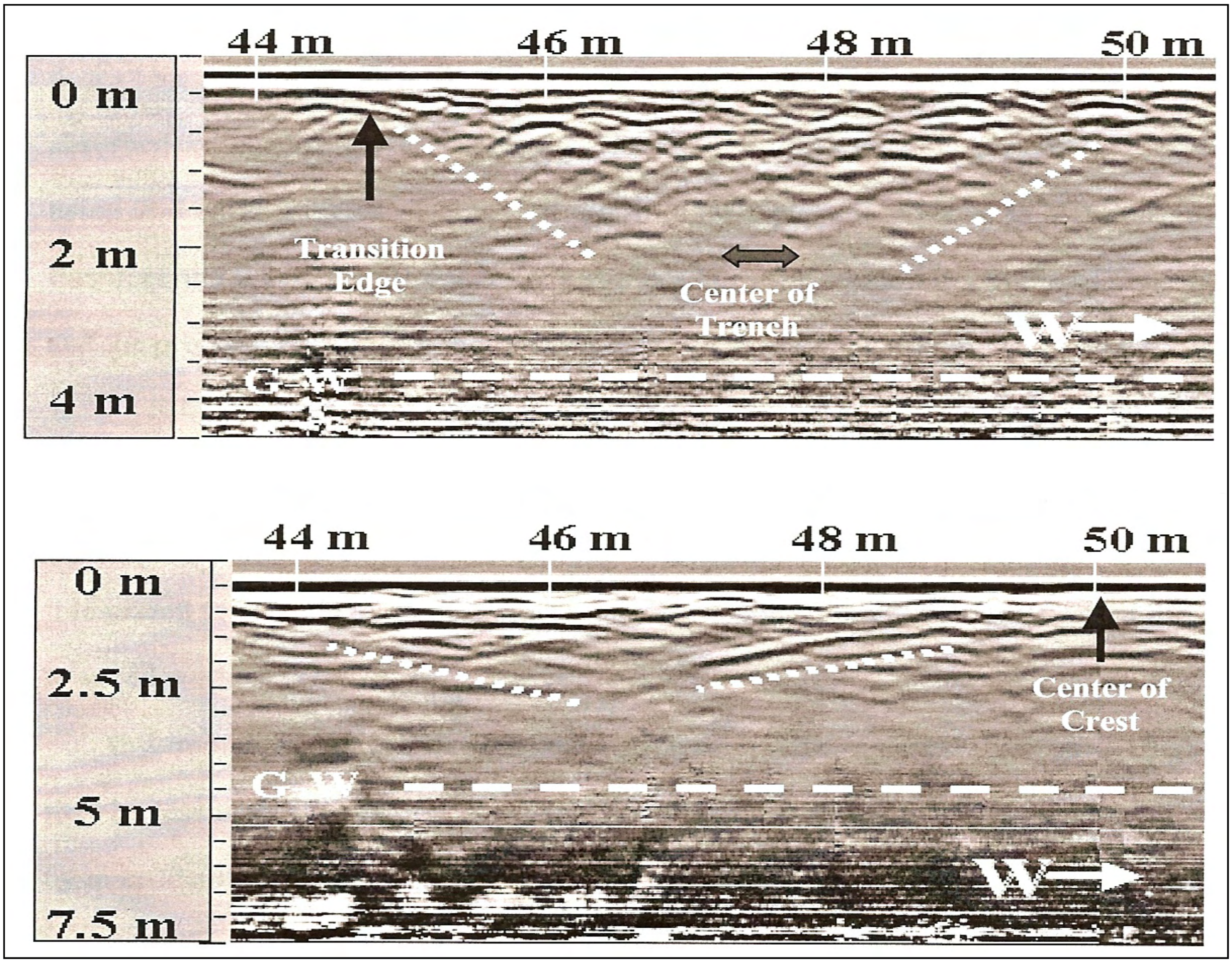

Figure 1. Comparison of 400 MHz (top) and 200 MHz Antenna (bottom). The 400 MHz profile demonstrates higher spatial resolution whose cross section is interpreted to show a boundary between undisturbed and mixed soil in a 'trench and cover' landfill. The 200 MHz profile exhibits pronounced attenuation of the GPR signal by ground water (GW) at 4 m depth.[4]

limited depth penetration. Lower frequency waves are not attenuated as rapidly and are capable of imaging targets at greater depth. Unfortunately, lower frequencies also provide inferior target resolution. Hence, the user of wave imaging technologies must select the optimal frequency based on target depth and size. A brief discussion of the thought process that goes into the selection of the antenna used for ground penetrating radar (GPR) surveys demonstrates the 'trade off' between depth of investigation and target resolution. A GPR system consists of a recorder and a variable-frequency transmitter/receiver antenna, with different antennae being used to provide greater or lesser depth penetration (and coincidently lesser or greater target resolution). The antennae generate and record the variable-frequency (25 MHz to 1,500 MHz) electromagnetic waves that penetrate into the ground and are reflected from lithological interfacies and objects that have a different dielectric constant than their host material. Reflected waves that return to the earth's surface are recorded by the antenna and used to generate a GPR profile which is not unlike a seismic profile in appearance (Figure 1). In order to effectively map a target using GPR, the frequency employed in the field must be capable of providing both the necessary penetration (given target depth) and spatial resolution (given target size). This may not always be possible.

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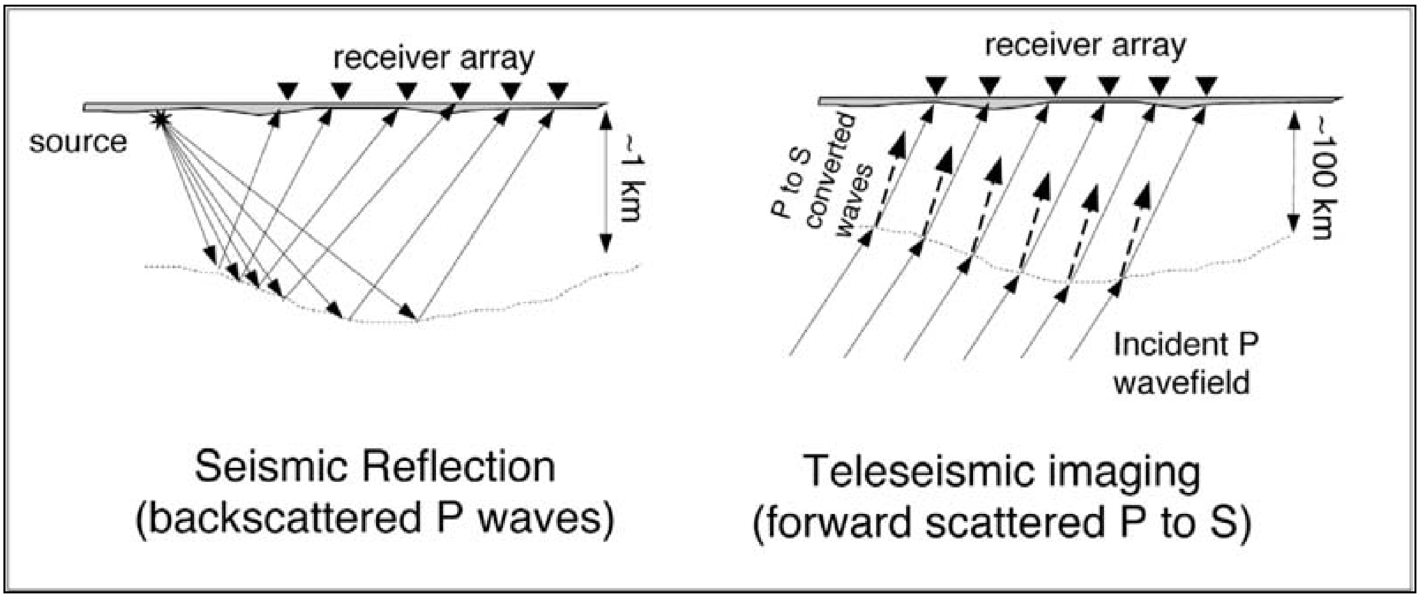

Figure 2. The key issue in using immense waves to image sites of interest lay in the difference in the primary recording band. Most seismic reflection data focus on the 10-100 Hz band while the major band for passive array imaging is around 0.03-2 Hz. The bandwidths are comparable, but the scales differ by two orders of magnitude.[6]

Theoretical vertical resolution (Fresnel Zone) can be taken as 0.25 of the wavelength (h) of the incident wave. As an example, we can calculate the resolution of a 100 MHz Antenna. A wave traveling at 100 MHz has a period (1/f) of 10 ns. Based on permittivity, we estimate a soil to have a velocity (V) equal to 0.06 m/ns. Therefore, h = V/f (0.25) = 0.15 m resolution. Note that a target smaller than 0.15 m in diameter may be missed by this antenna.

In Figure 1**,** an example GPR profile is presented for the purposes of illustration. In this figure, saturation of the soil at depths of about 4 m is evidenced by the observation that the GPR signal is effectively absorbed (attenuated) at increasingly greater depths. The 400 MHz antenna used for this survey was the appropriate frequency because it provided both the required depth of investigation and the prerequisite spatial resolution for effective interpretation. Simplistically, vertical resolution is a function of frequency.

Let us consider a second example where the average depth of facilities of interest is about 100 m below the surface and exploratory tunneling widths associated with those facilities range in diameter from about 1 to 3 m. As such depths of investigation are not feasible using current GPR technologies, but are achievable using certain seismic methods. According to Reynolds, large seismic sources can provide low frequencies using high energy low wave generation (such as the 8-Kilojoule Sparkarray) down to 1.2 kilometers depth.[5] However, these methods are not practical for use at such remote sites because the equipment is large in size and produces pronounced signals.

Other teleseismic methods using passive array imaging technologies, with seismic signals in the 0.03 to 2 Hz range, can be used to map the subsurface on a regional scale. Figure 2 compares the reflection and passive array geometries. Note the difference in scale that is related directly to the wavelength. In the reflection survey case (left), the weathered layer is evident. In the passive array imaging (right), the magnitude of scale relative to the wavelength covers an entire sedimentary basin. Based on the receiver array spacing and wavelength, it is virtually impossible to use teleseismic methods to image large facilities of interest even with substantive post-acquisition processing.

Proximity

Some investigative methods, referred to as remote sensing, are used to image the earth from large distances and do not require direct contact between sensors and the earth's surface. These methods use that part of the wave spectrum (in the range of greater than 103 MHz; electromagnetic, hyper-spectral, or infrared imagery) more practical for very shallow investigations. The question can be posed, 'Can we image deep tunnels (as opposed to shallower bunkers) at 'stand off' distance using platforms like unmanned aerial vehicles (UAVs)?' The answer is an emphatic 'No, not with existing technology!' The quintessential limitations have to do with signal diffusion and the principles of wave source frequency and depths of investigation.

Diffusion is caused by the number of media a wave must pass through to reach the target and then return to a sensor. Intuitively, the more surfaces of contrasting impedance the wave must pass through the greater the energy loss due to attenuation and scattering. In addition, natural and man made noises are increasingly introduced at greater 'stand off' distances making it impossible to pick out the anomalous signals to image deeper subsurface facilities of interest

	VOID	CAVE	MINE	SINK HOLE	UST	WATER TABLE
Gravity	G	G	G	G	A	G
Advantages	Unobtrusive and environmentally sound practice for sensitive areas; Light instrument survey package, direct response to mass deficit.					
Limitations	Stable leveling conditions and relatively quiet environment; Manpower intensive with slow surveying compared to other geophysical methods; Not effective in conditions of variable subsurface density and topography.					

Solution Matrix 1. Gravity Method.

Lower frequency waves are not attenuated as rapidly and are capable of imaging targets at greater depth. Unfortunately, lower frequencies also provide inferior target resolution.

A field observation of a 1 m diameter tunnel at a depth of 50 m convincingly demonstrates that the ground gradiometer clearly maps the structure in 2D profile. However, the same gravity method using an airborne platform at 200 m above ground cannot clearly map the tunnel anomaly due to the gravity deficit decay at greater distance. Additionally, residual anomalies are added to the profile as a function magnitude.[7]

Airborne electromagnetic (EM) surveys can often cover large expansive areas and have rapid post processing advantages. In much the same way that certain spectra of satellite imagery can detect plant stress and shallow surficial subsidence, airborne electromagnetic method surveys can indicate similar activity associated with tunneling. More direct and local follow-up geophysical survey methods can then be used to confirm that facilities of interest exist. The limitation of remote sensors to image deep targets brings us back to those non-invasive surface-based active and passive methods that are continually being developed to image deeper voids.

Current Best Technologies

Several geophysical surface-based technologies can be used to locate cavities that include facilities of interest. These methods include gravity, GPR, (electrical) resistivity, and surface seismic methods (MASW). The method(s) that should be used at any specific site depends on the site geology, and the depth and configuration of the voids. Methods discussed also include a decision matrix that is color coded such that Green signifies that the method is recommended, Amber recommended for certain conditions, and Red not recommended. Note the word 'mine' is in context to industrial underground mining and UST is an acronym for underground storage tank. The primary source for this primer is after Hanna, K. (2003): Applications of Geophysical Methods to Highway Related Problems. The more widely accepted geophysical methods to detect voids are summarized below: [8]

Gravity: The gravity method measures small spatial differences in the strength of the gravitational field of the earth. If a void is close enough to the ground surface and sufficiently large, a small decrease in the regional gravitational field of the earth will be observed across and in proximity to the void. Voids can produce identifiable and quantitatively

	VOID	CAVE	MINE	SINK HOLE	UST	WATER TABLE
GPR	G	R	A	A	G	A
Advantages	High resolution for quantitative analysis; On site data collection quality control; Relatively rapid data acquisition in ideal conditions.					
Limitations	Cannot be used in highly conductive / saturated soils; Experienced interpretation; Comparatively shallow depth penetration.					

Solution Matrix 2. Ground Penetrating Radar (GPR) Method.

interpretable-sized anomalies when they are large and fairly near the ground surface, however the smaller anomalies generated by smaller voids at depth may not be identifiable due to the presence of background noise. Clearly, the size of a gravity anomaly depends on the size and depth of the void, and at some point (re: increasing depth) it cannot be confidently identified or recognized. Thus, it is important to measure the gravity field with as much accuracy as possible. The biggest limitation of the gravity technique is that data acquisition, processing, and interpretation is very slow, relative to other available geophysical technologies. Additionally, the interpretation of gravity data and subsequent produced images cannot normally be done in real time. (see Solution Matrix 1. Gravity Method.)

Ground Penetrating Radar (GPR): Ground penetrating radar tools can be used to locate shallow cavities. However, depth of penetration is very dependent on the site conditions, in particular on the resistivity of ground moisture and clay content. Best results will generally be obtained in unsaturated soil/rock where no clay is present. For voids at depth, the most serious issue is penetration. Therefore, an antenna with a sufficiently low frequency to penetrate to the required depth is needed. Unfortunately, lower frequency antennae may not provide the required spatial resolution. The GPR tool is often ideal for cavity detection because data can be acquired very rapidly and interpreted by an experienced user in real time. Also, the antenna can be dragged across the ground and does not need to be otherwise coupled to the earth.

Resistivity: Since an air-filled void is usually much more resistive than its host rock, resistivity methods can often be used to locate them. (see Solution Matrix 3. Resistivity Method) However, the voids have to be fairly shallow, typically within 30 m of the ground surface. This is partly because the electrode array needed to investigate to greater depths becomes excessively long and cumbersome. In addition, being a long array, the resistivity results become influenced by other geological conditions, both along the traverse line and laterally. If the void is filled with water, its resistivity contrast with the host rocks may be quite small. The fluid-filled void may even be characterized by a resistivity low, depending on the salinity or acidity of the water filling the void. The measurement of resistivity, or more correctly apparent resistivity (since the value read may include several layers each with different resistivity), can be done using multiple electrodes placed into the ground. The electrodes are simply metal stakes about 0.3 m long that are coupled to the ground. The more sophisticated tools are automated and very user friendly, and the output is a profile image of the subsurface on which voids typically show up as bull's eyes. On the downside, ground-coupled

	VOID	CAVE	MINE	SINK HOLE	UST	WATER TABLE
Resistivity	G	G	G	G	R	G
Advantages	Successful at locating cavities if they are large enough compared to their depth; CCR (drag line) method is time effective on well coupled ground in optimal conditions; Data can be interpreted in terms of lithologic and / or geohydrologic model.					
Limitations	Labor intensive if using standard traverse; Hard, dry or stony conditions require additional survey adjustements; metal fences and power lines may add noise into data.					

Solution Matrix 3. Resistivity Method.

resistivity data cannot be acquired nearly as rapidly as GPR data, as the electrodes must be inserted directly into the ground.

(sometimes called ringing) as the void is crossed. The fourth parameter is a shift in the peak frequency toward lower frequencies, caused by trapped

	VOID	CAVE	MINE	SINK HOLE	UST	WATER TABLE
MASW	A	A	A	A	R	G
Advantages	Cost and time effective over other seismic methods; Effective in areas of high background noise; Unobtrusive and environmentally sound practice for sensitive areas; Better method for embedment and bedrock depths.					
Limitations	External constraints cannot be applied during processing; Long geophone arrays, Limited resolution and depth (D≤50m.)					

Solution Matrix 4. Multichannel Analysis of Surface Waves (MASW) Method.

Multichannel Analysis of Surface Waves (MASW): This method uses Rayleigh waves to detect fracture zones and associated voids. Rayleigh waves, also known as surface waves, involve particle motion that is counterclockwise with respect to the direction of propagation. The Rayleigh waves that are generated by a primary source are typically perturbed when they pass across a subsurface void. Four parameters are usually observed. The first is an increase in the travel time of the Rayleigh wave as the fracture zone above the void is crossed. The second parameter is a decrease in the amplitude of the Rayleigh wave. The third parameter is reverberations waves. The effective depth of penetration one-half of the wavelength of the lowest recorded Rayleigh wave frequency. MASW technology is relatively new, and its application to void detection is not yet thoroughly understood or appreciated. However, this technology has great potential because data can be acquired and interpreted very rapidly using land streamers and real time interpretation software.

Conclusion

Investigators recognize that there is no single imaging method that can find, characterize and assess all facilities of interest. Rather, methods can be viewed from a 'toolbox' perspective, where more than one method is often applied to the problem because multiplicity reduces the possibility for misinterpretation. Dr. Jeff Daniels recently summarized some simple truths about the limitations of applied geophysics that focused on the depth and resolution problem as discussed earlier. Moreover, he observed that the geophysical community generally conducts surveys in ideal conditions in order to establish baseline data. But, once heterogeneity and variation in topography is introduced, imaging becomes much more problematic.[9]

On a positive note, with time, effort, energy and resources – many of the current limitations can be overcome.

What are the current trends for improving geophysical methods? The general consensus from experts attending a recent U.S. Army Advanced Concept on Shallow Tunnel Detection in Mississippi (February, 2006) is one of continued flexibility and interoperability of geophysical survey methods. The focus is on the development of portable imaging tools which allow the operator to interpret geophysical data on site and communicate interpretations back to headquarters. Recent technological improvements include new composite materials that reduce GPR antenna size yet generate higher-amplitude/ lower-frequency waves. Recent improvements in gravity methods will greatly reduce the time required to delineate subsurface voids. Current geophysical research combined with its infusion into real time wireless systems will better enable the warfighter to image the subsurface. However, additional advances need to be made because the detection of facilities of interest in austere environments requires geophysical ground sensor hardware that is miniaturized and emits relatively undetectable signals.

Passive geophysical methods that monitor facilities of interest continue to be developed as well. These passive methods measure signals well below human hearing, such as vibrations

Figure 3. System configuration for real-time gravity and GPS data acquisition. The Tucker SnoCat and the CG-3M gravity meter with the rover GPS antenna mounted on the meter (left). Laptop computer and the Leica GPS controller inside the SnoCat (right).[10]

from engines or pressure differences caused by the opening and closing of doors. Such subtle signals are detected by passive sensors whose vibrations are generally categorized as microseismic waves.

Improved real time subsurface imaging has solid potential to find, characterize and assess facilities of interest. This will give our leaders the information they need in order to dissuade and deter our potential adversaries. If diplomacy fails, geophysical methods can assist the United States and our Allies to swiftly defeat a determined enemy's underground facilities housing WMD, ballistic missile, and senior leadership. By further developing geophysical technologies, we can both greatly increase the confidence level of locating facilities of interest and reduce collateral and environmental damage caused by neutralizing these threats.

For more detailed information on geophysical methods, a primer titled Applications of Geophysical Methods to Highway Related Problems is available on-line at www.cflhd.gov/geotechnical.

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Special acknowledgement is made for the collaboration and assistance in composing this work to Dr. Neil Anderson, Department of Geological Sciences and Engineering at the University of Missouri, Rolla. He holds his Ph.D. from the University of Calgary.

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Table 1. Conventional Geophysical Technologies.

Geophysical Method	Measured Parameter(s)	Physical Property or Properties	Physical Property Model (Geotech Application) n	Typical Site Model (Geotech Application)
Shallow Seismic Refraction	Travel times of refracted seismic energy (p- or s-wave). n	Acoustic velocity (function of elastic moduli and density).	Acoustic velocity/ depth model.	Geologic profile.
Shallow Seismic Reflection	Travel times and amplitudes of reflected seismic energy (p-or s-wave).	Density and acoustic velocity (acoustic velocity is a function of elastic moduli and density).	Acoustic velocity/ depth model.	Geologic profile.
Seismic Tomography	Travel times and amplitudes of seismic energy (p- or s-wave).	Density and acoustic velocity (acoustic velocity is a function of elastic moduli and density).	Model depicting spatial variations in acoustic velocity.	Geologic profile.
Ground-Penetrating Radar (GPR)	Travel times and amplitudes of reflected pulsed electromagnetic energy.	Dielectric constant, magnetic permeability, conductivity and EM velocity.	EM velocity/depth model.	Geologic, material or structure profile.
Electromagnetics (EM)	Response to natural/induced electromagnetic energy. n	Electrical conductivity and inductance.	Conductivity/depth model.	Geologic/ hydrologic profile.
Electrical Resistivity	Potential differences in response to induced current. n	Electrical resistivity.	Resistivity/depth model.	Geologic/ hydrologic profile.
Induced Polarization (IP)	Polarization voltages or frequency dependent ground resistance.	Electrical capacitance.	Capacitance/depth model.	Model depicting spatial variations in clay content (or metallic mineralization).
Self Potential (SP)	Natural electrical potential differences.	Natural electric potentials.	Model depicting spatial variations in natural electric potential of the subsurface.	Hydrologic model (seepage through dam or fractured bedrock, etc.).
Magnetics	Spatial variations in the strength of the geomagnetic field.	Magnetic susceptibility and remnant magnetization.	Model depicting spatial variations in magnetic susceptibility of subsurface.	Geologic profile or map (location of faults, variable depth to bedrock, etc.).
Gravity	Spatial variations in the strength of gravitational field of the earth.	Bulk density.	Model depicting spatial variations in the density of the subsurface.	Geologic profile or map (location of voids, variable depth to bedrock, etc.).

	VOID	CAVE	MINE	SINK HOLE	UST	WATER TABLE
Gravity	G	G	G	G	A	G
GPR	G	R	A	A	G	A
Resistivity	G	G	G	G	R	G
MASW	A	A	A	A	R	G

Combined Matrix

Stanford Won the DARPA 2005 Grand Challenge!

Robert A. Pfeffer, Physical Scientist

Well, it's official. The Defense Advanced Research Projects Agency (DARPA) has announced a winner of their second Grand Challenge, which is an off-road race for robotic vehicles over a 130-mile desert terrain. In order to win, a vehicle had to traverse the distance in less than ten hours with no human intervention, meaning no remote control operation, and no pre-programming.

The Stanford University Racing Team entry covered the course in six hours, 53 minutes and 8 seconds. That equates to a blistering 19.1 miles per hour! The stock Diesel-powered Volkswagen Tuareg R5 named "Stanley" did an outstanding job and one of the results was a two-million dollar prize for the Stanford University Racing Team.

Photo by Stanford University.

Do you think Stanford tapped into some new power source (Red Bull) from their sponsor?

Coming in second and third, both in less than ten hours, were the two Carnegie Mellon entries Sandstorm (seven hours, four minutes and 50 seconds) and Highlander (seven hours and 14 minutes). Two others, GrayBot/KAT-5 (seven hours, 30 minutes and six seconds) and TerraMax (greater than ten hours), completed the race.

A total of 23 finalists competed this year out of the 195 teams from 36 states and four foreign nations that originally filed applications. No entry finished the Challenge in 2004, so DARPA and the Services must be pleased at the steep learning curve the teams underwent. This success means the age of autonomous Army vehicles has rapidly accelerated. It also means future autonomous electronic controls will be extremely sophisticated but potentially susceptible to a wide range of undesirable electromagnetic environments. Expect to see a version of the Stanley drive-by-wire system that controlled all of "Stanley's" movement incorporated in future military vehicles. The utility of this technology for CBRN reconnaissance (and a myriad of other things) is obvious.

For more reading on the DARPA 2005 Grand Challenge, go to www.grandchallenge.org.

TRINITY – Day of Two Dawns (Part III)

Mr. Martin W. Moakler, Jr.
United States Army Nuclear and Chemical Agency

Let us see - where are we in this story? In Part I (published in the Spring/Summer 2005 issue of the *NBC Report*), the Manhattan Engineer District organizations and prominent project facilities were described. In Part II (published in the Fall/Winter 2006 issue of the *NBC Report*), presidential involvement in the Manhattan Project was addressed. In this final part of the story, the focus is on the Trinity shot and eye witness accounts.

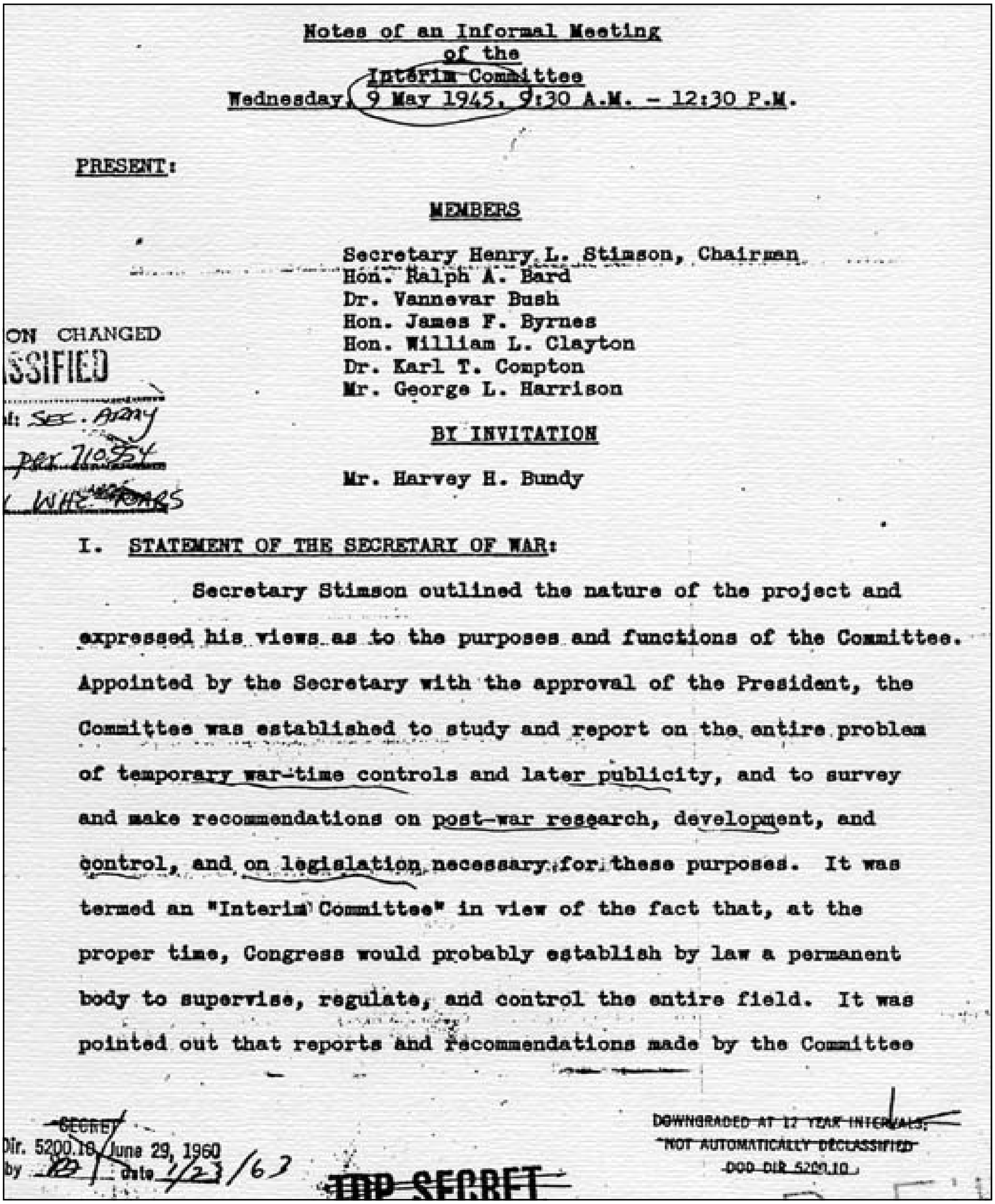
Events Leading to Trinity

Within twenty-four hours of Franklin D. Roosevelt's death, Harry Truman was told about the atomic bomb by two men: Henry L. Stimson and James F. Byrnes (Rhodes, 1986). Stimson, the Secretary of War under FDR, continued to serve President Truman in that cabinet position.

Truman called a cabinet meeting after taking the oath of office on the evening of Roosevelt's death on April 12, 1945. After that meeting, Truman remembered Stimson telling Truman about an immense project to develop a new explosive with unbelievable destructive power, but that was all that he felt free to say at the time (Rhodes, 1986). Truman would not get a formal brief about the Manhattan project until April 25, 1945, thirteen days later. Byrnes talked to Truman the next day. FDR had positioned Byrnes to be the "assistant President" in his cabinet position of Director of Economic Stabilization and later as the Director of War Mobilization. Basically, FDR ran the war and foreign affairs and Byrnes ran the country. Byrnes told Truman the next day that an explosive powerful enough to destroy the whole world was being perfected and that the bomb might put us in a position to dictate our terms at the end of the war (Rhodes, 1986). One week later, Byrnes became Secretary of State.

On April 25, 1945, Stimson brought General Groves to the president to provide a twenty-four page report on the status of the Manhattan Project (Rhodes, 1986). President

Truman takes the oath of office.



Notes of an Informal Meeting
of the
Interim Committee
Wednesday, 9 May 1945, 9:30 A.M. - 12:30 P.M.

PRESENT:

MEMBERS

Secretary Henry L. Stimson, Chairman
Hon. Ralph A. Bard
Dr. Vannevar Bush
Hon. James F. Byrnes
Hon. William L. Clayton
Dr. Karl T. Compton
Mr. George L. Harrison

BY INVITATION

Mr. Harvey H. Bundy

ON CHANGED
SSIFIED

I. STATEMENT OF THE SECRETARY OF WAR:

Secretary Stimson outlined the nature of the project and expressed his views as to the purposes and functions of the Committee. Appointed by the Secretary with the approval of the President, the Committee was established to study and report on the entire problem of temporary war-time controls and later publicity, and to survey and make recommendations on post-war research, development, and control, and on legislation necessary for these purposes. It was termed an "Interim Committee" in view of the fact that, at the proper time, Congress would probably establish by law a permanent body to supervise, regulate, and control the entire field. It was pointed out that reports and recommendations made by the Committee

~~SECRET~~
Dir. 5200.10 June 29, 1960
by ... date 1/23/63

~~TOP SECRET~~

~~DOWNGRADED AT 12 YEAR INTERVALS; NOT AUTOMATICALLY DECLASSIFIED~~
~~DOD DIR 5200.10~~

Minutes of First Interim Committee Meeting.

Truman's focus was distracted as he was presently having trouble with Stalin at the moment and wanted to address that problem. Stimson insisted that Truman read the report. Groves noted that Truman was distracted on foreign relations and the Russian situation, but Truman made it very definite that he was in agreement with the need for the project (Rhodes, 1986). Shortly after this meeting, based upon Stimson's encouragement, President Truman authorized the stand-up of two committees: the Targeting Committee and the Interim Committee. The Targeting Committee was run by the military to make recommendations where to employ the atomic bomb. The Interim Committee was a political body to make recommendation on publicity, resources, and atomic bomb employment

MG Leslie Groves, commander of the Manhattan Engineer District.

President Truman announces VE Day to the nation (May 8, 1945).

policies and legislation (Rhodes, 1986).

Victory in Europe was declared as the Nazi empire collapsed on May 8, 1945. This allowed the United States to focus on the Pacific front. Japan was the target of the atomic bomb. The Trinity test shot, the first atomic bomb detonation, was planned for July 1945 (Rhodes, 1986). Meanwhile, back at the ranch …

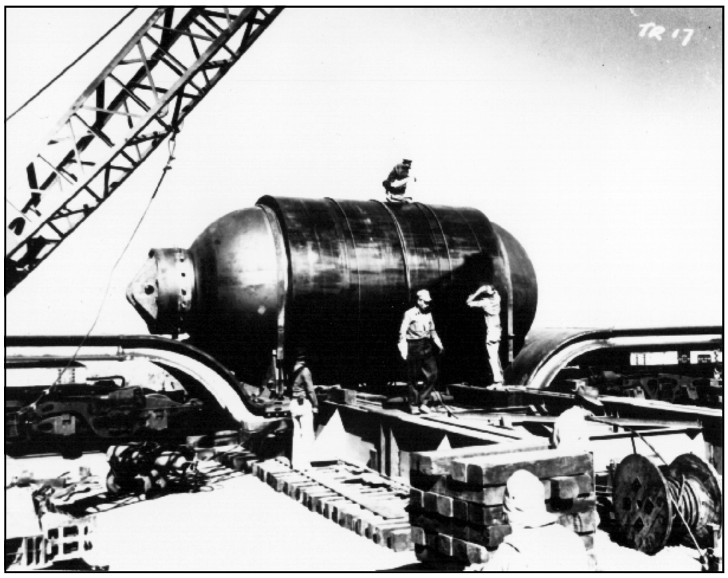
Preparing for Trinity

Development of the uranium gun-type atomic weapon, later called Little Boy, moved ahead confidently. Scientists were certain of the gun-type design's reliability (LASF PR, 1986). However, it was with the plutonium implosion weapon, which compressed a sub-critical mass of plutonium to supercriticality by high explosives, that the scientists had questions. They felt that the implosive device needed to be tested (LASF PR, 1986). This would also give the scientists the controlled environment to conduct detailed measurements to determine the magnitude of the atomic bomb's effects. So it was decided. One-third of the nation's atomic weapon stockpile would be secretly tested in New Mexico (LASF PR, 1986).

In March 1944, Dr. Kenneth T. Bainbridge became the

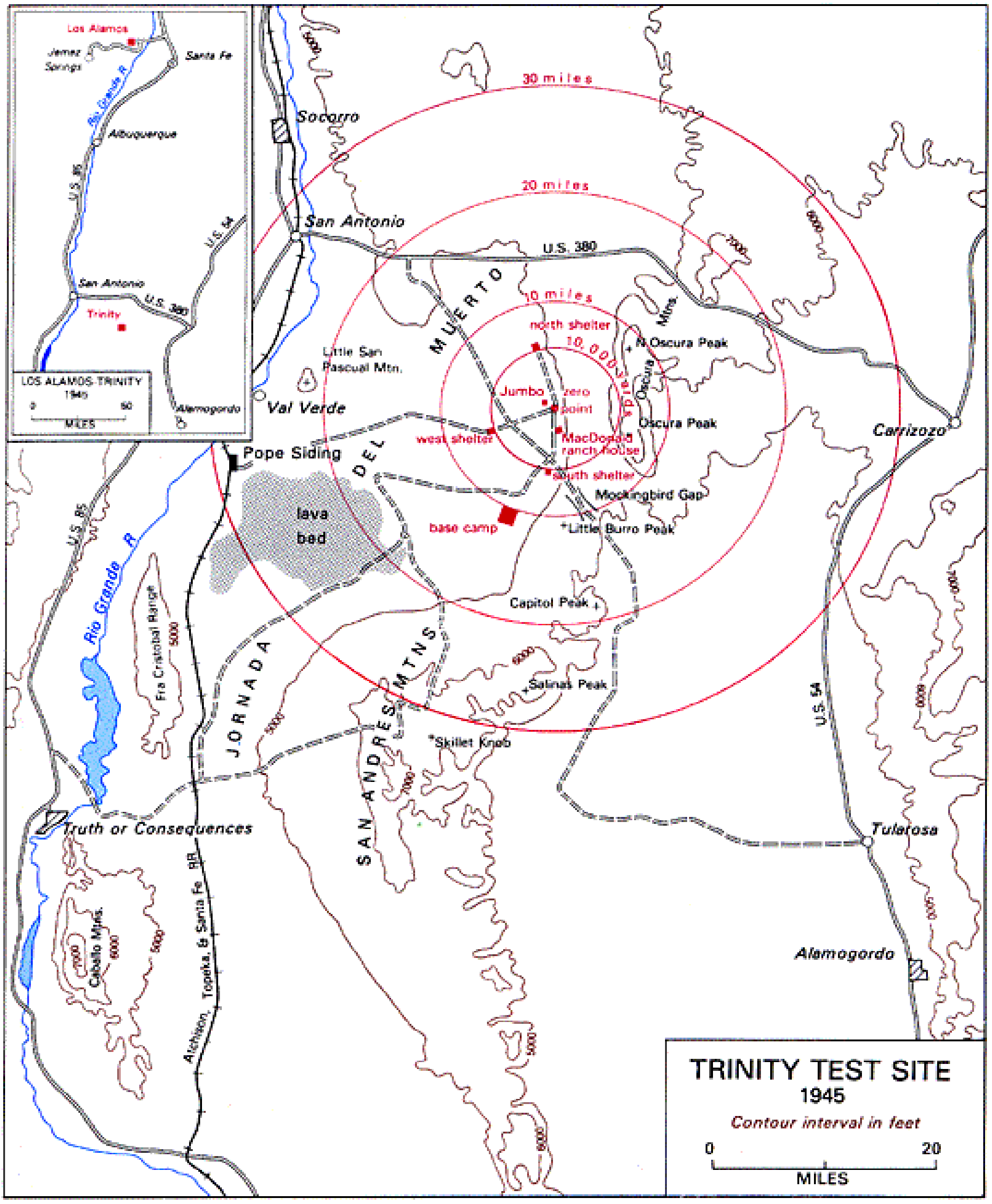
Dr. Kenneth T. Bainbridge, Trinity Test Director.

Trinity Test Director. His duties were to "make preparations for a field test in which blast, earth shock, neutron and gamma radiation would be studied and complete photographic records made of the explosion and atmospheric phenomena connected with the explosion" (LASL PR, 1986, p. 31). Since the amount of plutonium was so scarce, a steel containment vessel was designed to contain the atomic explosion and prevent the scattering of the precious plutonium if there was a fizzle. Manhattan Engineer District Commander Leslie Groves ordered the container, called "Jumbo," to be built at a cost of more than $12 million



Jumbo Arrives Before Trinity Shot. (Atomic Archive, 2005).

Jumbo was the largest item that had ever been shipped by rail, and several trestles on the railroads from the factory that built it in Ohio to the Trinity site had to be rebuilt. By the time Jumbo arrived, the production of plutonium had increased and Oppenheimer believed that there was less chance of a fizzle. Consequently, the container



Trinity Site.

was relegated to the sidelines and hung not far from Ground Zero to serve as an indicator of the power of the bomb (Atomic Archive, 2005).

The construction of the Trinity site was done during the spring of 1945. By June, Bainbridge was ready to calibrate the instruments that would be used to measure the blast, heat and radiation of the "Gadget" using a 100-ton stack of high explosives tagged with fission products from the Hanford Nuclear Reactor (LASF PR, 1986).

The 100-ton test of high explosives was the largest man-made explosion up to that time (LASF PR, 1986). This explosion made it possible for the Los Alamos scientists to refine their instruments before the much larger blast anticipated from the Gadget (LASF PR, 1986). The design of the Gadget had been fixed in February 1945 when Groves ordered a design freeze so that the device could be ready by July (LASF PR, 1986). A conservative solid-core design of the Gadget required the development of detonators, fuses and high-explosive lenses that were not yet perfected. The Los Alamos scientists and technicians succeeded in producing all of the components of the device successfully by July 13 (LASF PR, 1986). On that day, assembly of the Gadget began at the Trinity site. The senior scientists started a betting pool on the explosive yield of Trinity with a one-dollar entry fee (Rhodes, 1986). Edward Teller picked 45,000 tons TNT equivalent. Hans Bethe bet on 8,000 tons. Oppenheimer wagered a modest 300 tons. Enrico Fermi was heard taking side-bets that the bomb would incinerate New Mexico. Norman Ramsey opted for failure and bet zero.

100-ton High Explosive Test & Calibration Shot.

Dr. Isidor Rabi arrives a few days before the test and took the only remaining bet for 18,000 tons (Rhodes, 1986).

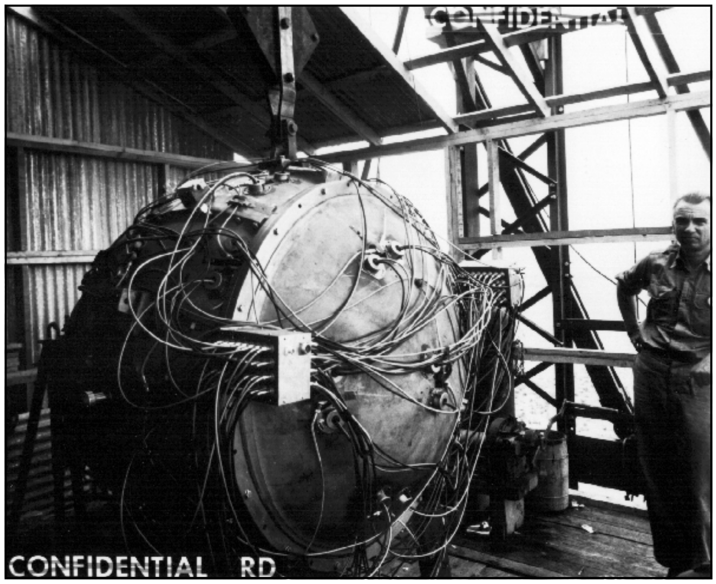
The Army had leased the David McDonald ranch and renovated if for a field laboratory and military police station (Rhodes, 1986). The McDonald ranch was about 3,400 yards south-east from ground zero. Three observation bunkers were built 10,000 yards from ground zero: north, west, and south (the command center). A VIP observation point was established on a scenic overlook hill named Compañia twenty miles northwest of ground zero.

The Gadget was assembled at the McDonald ranch (Rhodes, 1986). A crew led by Norris Bradbury, a professor of physics at Stanford University, assembled the high-explosive lenses that had been brought from Los Alamos the day before (Rhodes, 1986). Initially, the plutonium would not fit in the Gadget (Rhodes, 1986). It had expanded due to the day's high heat. When allowed to cool down in the shade, the pit reduced in size and easily fit in the assembly. After the tamper and the active material were inserted into the spherical case, the final high-explosives were inserted. Saturday, July 14, 1945, the assembled Gadget was hoisted to the top of the 100-foot tower on which it would be detonated. The firing unit was wired by late afternoon. The detonation was scheduled for 4 a.m., Monday, July 16 (Rhodes, 1986).

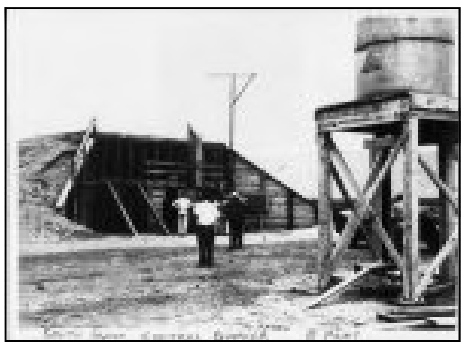
As the test approached, the weather worsened. A thunderstorm broke over the site late on the evening of July 15 (Rhodes, 1986). The test was postponed from 4 a.m. to 5:30 a.m. to avoid the possibility of a rain-out of fission products from the bomb cloud due to rain (Rhodes, 1986). Members of the health physics team were ready in nearby settlements to evacuate the population if the test greatly exceeded expected yields (Rhodes, 1986). Groves called the governor of New Mexico to alert him that an evacuation of the state might be required (Rhodes, 1986).

As the meteorologists predicted, the weather cleared and the countdown for the test was begun at 5:10 a.m. At 5:29:45 a.m., the gadget exploded, evaporating the tower on which it stood (Rhodes, 1986). Radio-chemical measurements confirmed a yield of 18.6 KT, which was nearly four times what Los Alamos had expected (Rhodes, 1986). Rabi had won the pot.

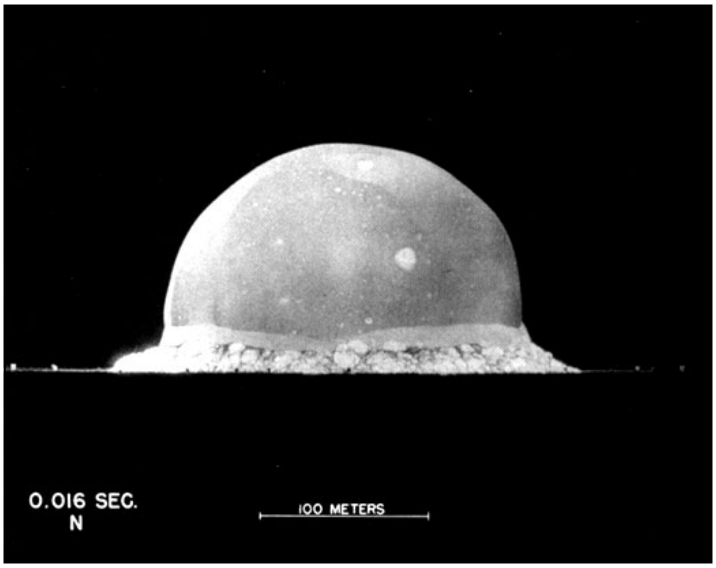
McDonald's Ranch House.



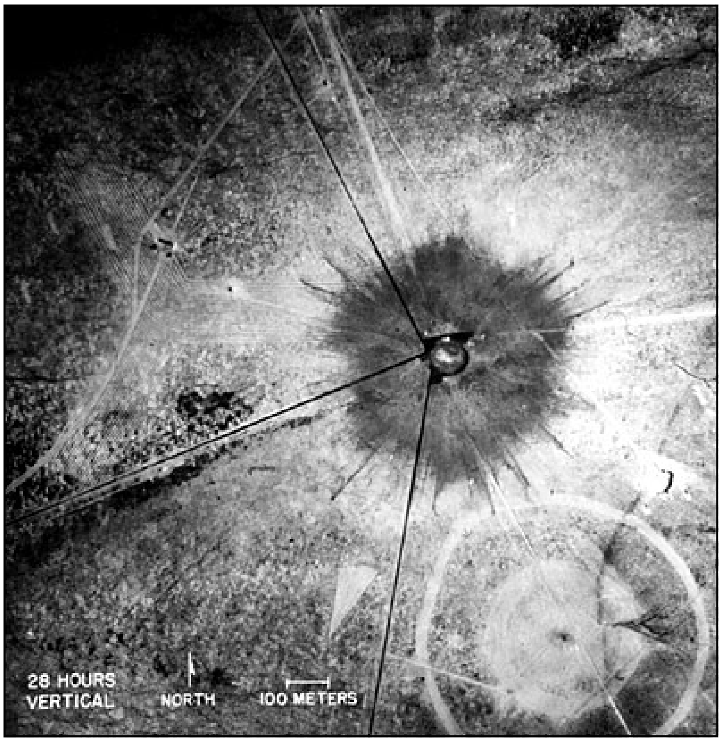
Gadget in the Tower.



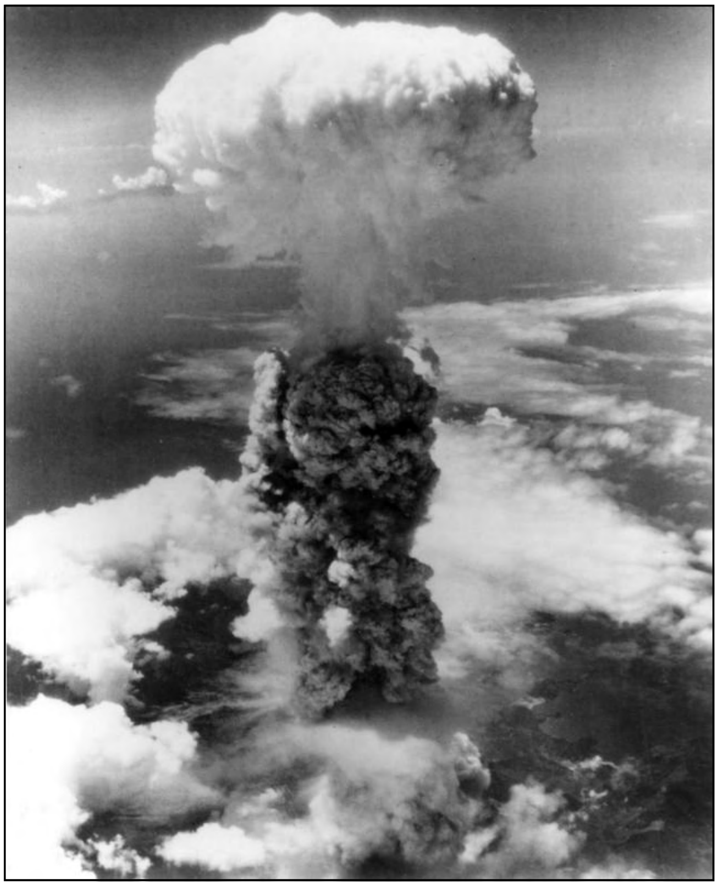
S-10000 Observation Bunker.



Trinity Detonation.



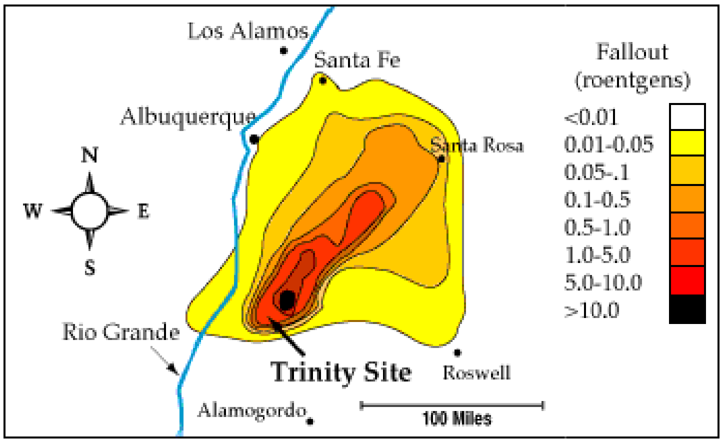
Aerial shot of Trinity Ground Zero. (100-ton Test Was Done Southeast of GZ).



Trinity Mushroom Cloud Formed.

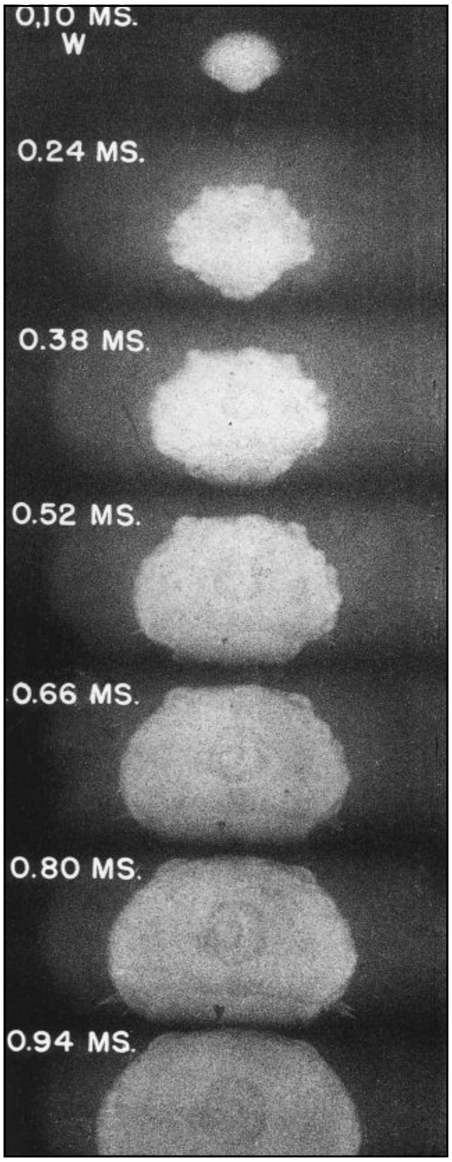
Trinity Tower After the Shot.

Recreated Trinity Fallout Footprint.



Personal Observations

Sparkey Harkey and his son Richard were standing in the gloom before dawn waiting for a train at Ancho when the bomb went off. “Everything suddenly got brighter than daylight,” Richard Harkey remembers today. “My dad thought for sure that the locomotive had blown up (Thompson, 1995, p 1).



Trinity Photos Time Sequenced.

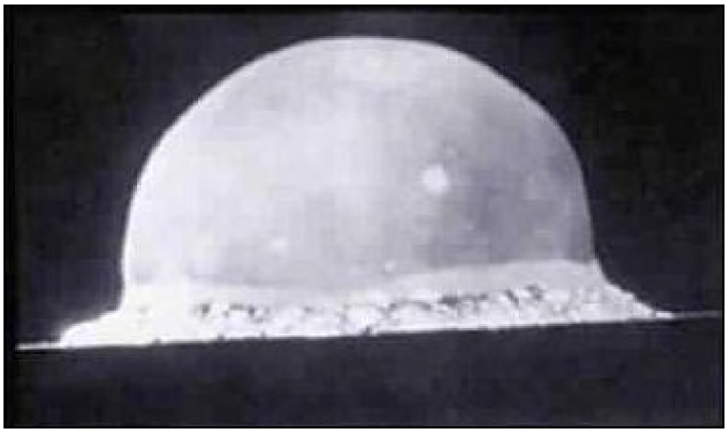
Oppenheimer mused (Rhodes, 1986):

“We knew the world would not be the same. … I remembered the line from the Hindu scripture, the Bhagavad-Gita: Vishnu is trying to persuade the Prince that he should do his duty and to impress him he takes on his multi-armed form and says, ‘Now I am become Death, the destroyer of worlds’ (p. 676).

When it went off, in the New Mexico dawn, that first atomic bomb, we thought of Alfred Nobel, and his hope, his vain hope, that dynamite would put an end to wars. We thought of the legend of Prometheus, of that deep sense of guilt in man’s new powers, that reflects his recognition of evil, and his long knowledge of it (p. 676)”.

Emillio Segre, back in the Base Camp, imagined apocalypse (Rhodes, 1986):

The most striking impression was that of an overwhelmingly bright light. . . . I was flabbergasted by the new spectacle. We saw the whole sky with unbelievable brightness in spite of the very dark glasses that we wore. . . . I believed that for a moment I thought the explosion might set fire to the atmosphere and thus finish the earth. . . . (p. 673).



Trinity Blast wave seen.

Trinity Director Bainbridge stated “No one who saw it could forget it, a foul and awesome display.” . . . Later at S-10000, Bainbridge stated to Oppenheimer “Now we are all sons of bitches” (Rhodes, 1986, p. 675).

MG Groves remembers, “When Farrell came up to me, his first words were, ‘The war is over.’ My reply was, ‘Yes, after we drop two bombs on Japan’ (p. 676)”.

Robert Serber, author of the Los Alamos Primer stated, “The grandeur and magnitude of the phenomenon were completely breath-taking.”

Color Photo of Trinity Shot.

Numerous personal observations of the Trinity event were captured. They now reside in the U.S. National Archives and can be found under Record Group 227, OSRD-S1 Committee, Box 82 folder 6, "Trinity." I have included two accounts from prominent scientists: Luis Alvarez and Enrico Fermi.

Dr. Luis W. Alvarez – Detonation Group Leader.

An Eye-Witness Account of the Trinity Shot on Monday Morning at 5:30 AM - 16 July 1945
by

L. W. Alvarez

I was kneeling between the pilot and co-pilot in B-29 No. 384 and observed the explosion through the pilot's window on the left side of the plane. We were about 20 to 25 miles from the site and the cloud cover between us and the ground was approximately 7/10. About 30 seconds before the object was detonated the clouds obscured our vision of the point so that we did not see the initial stages of the ball of fire. I was looking through crossed polaroid glasses directly at the site. My first sensation was one of intense light covering my whole field of vision. This seemed to last for about 1/2 second after which I noted an intense orange red glow through the clouds. Several seconds later it appeared that a second spherical red ball appeared but it is probable that this apparent phenomenon was caused by the motion of the airplane bringing us to a position where we could see through the cloud directly at the ball of fire which had been developing for the past few seconds. This fire ball seemed to have a rough texture with irregular black lines dividing the surface of the sphere into a large number of small patches of reddish orange. This thing disappeared a few seconds later and what seemed to be a third ball of fire appeared again and I am now convinced that this was all the same fire ball which I saw on two separate occasions through a new hole in the undercast.

When this "third ball" disappeared the light intensity dropped considerably and within another 20 seconds or so the cloud started to push up through the undercast. It first appeared as a parachute which was being blown up by a large electric fan. After the hemispherical cap had emerged through the cloud layer one could see a cloud of smoke about 1/3 the diameter of the "parachute" connecting the bottom of the hemisphere with the undercast. This had very much the appearance of a large mushroom. The hemispherical structure was creased with "longitude lines" running from the pole to the equator. In another minute the equatorial region had partially caught up with the poles giving a flattened out appearance to the top of the structure. In the next few minutes the symmetry of the structure was broken up by wind currents at various altitudes so the shape of the cloud cannot be described in any geometrical manner. In about 8 minutes the top of the cloud was at approximately 40,000 feet as close as I could estimate from our altitude of 24,000 feet and this seemed to be the maximum altitude attained by the cloud. I did not feel the shock wave hit the plane but the pilot felt the reaction on the rudder through the rudder pedals. Some of the other passengers in the plane noted a rather small shock at the time but it was not apparent to me.

Enrico Fermi – Theoretical Group Leader.

My Observations During the Explosion at Trinity on July 16, 1945
by

E. Fermi

On the morning of the 16th of July, I was stationed at the Base Camp at Trinity in a position about ten miles from the site of the explosion.

The explosion took place at about 5:30 A.M. I had my face protected by a large board in which a piece of dark welding glass had been inserted. My first impression of the explosion was the very intense flash of light, and a sensation of heat on the parts of my body that were exposed. Although I did not look directly towards the object, I had the impression that suddenly the countryside became brighter than in full daylight. I subsequently looked in the direction of the explosion through the dark glass and could see something that looked like a conglomeration of flames that promptly started rising. After a few seconds the rising flames lost their brightness and appeared as a huge pillar of smoke with an expanded head like a gigantic mushroom that rose rapidly beyond the clouds probably to a height of 30,000 feet. After reaching its full height, the smoke stayed stationary for a while before the wind started dissipating it.

About 40 seconds after the explosion the air blast reached me. I tried to estimate its strength by dropping from about six feet small pieces of paper before, during, and after the passage of the blast wave. Since, at the time, there was no wind I could observe very distinctly and actually measure the displacement of the pieces of paper that were in the process of falling while the blast was passing. The shift was about 2 1/2 meters, which, at the

time, I estimated to correspond to the blast that would be produced by ten thousand tons of T.N.T.

That was the end of Trinity, but it was the beginning of the Atomic era. The story continues next time with the 509th Composite Group, its commander LtCol Paul Tibbets, the B-29 aircraft named Enola Gay and the city named Hiroshima.

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His email address is moakler@usanca-smtp.army.mil

Bainbridge and Some of his Test Team at Ground Zero.

Secretary of War Stimson (right) and Secretary of State Byrnes (left).

The Trinity Test Tower.

Groves and Oppenheimer at Ground Zero.

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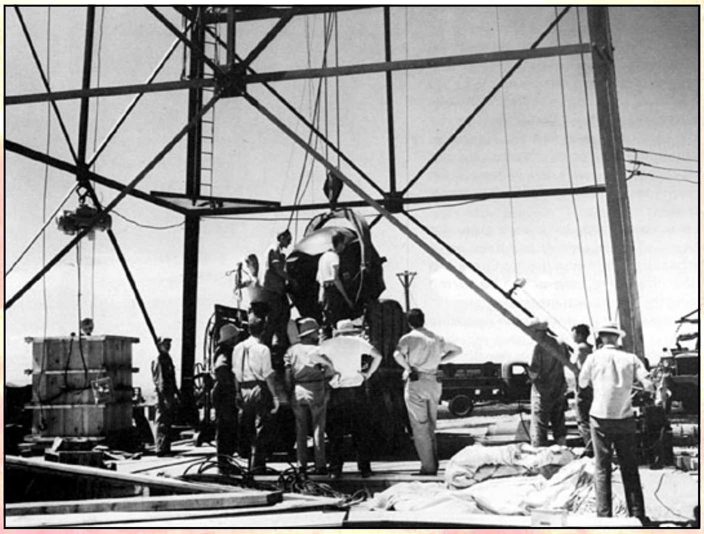
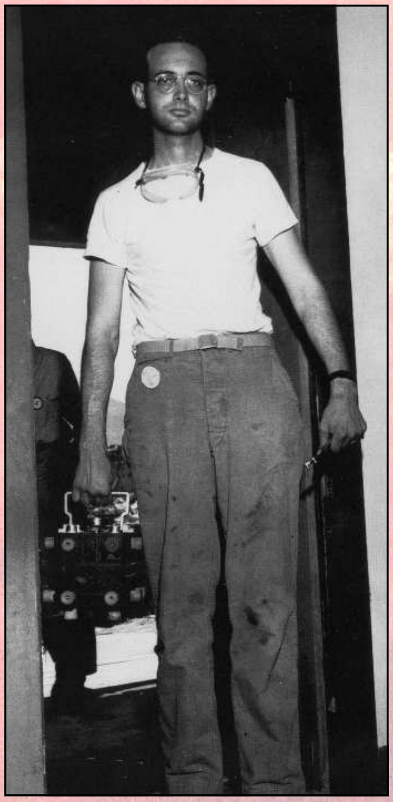
NOTE: Unless noted, all photographs were found on the Manhattan Project Heritage Preservation Association, Inc website at http://www.childrenofthemanhattanproject.org/intex.htm

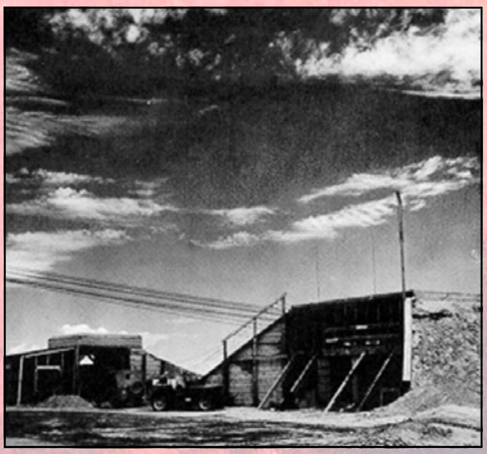
Jumbo Hung in its Tower.



Hoisting the Gadget.



Plutonium Delivered by Sedan for Final Assembly.

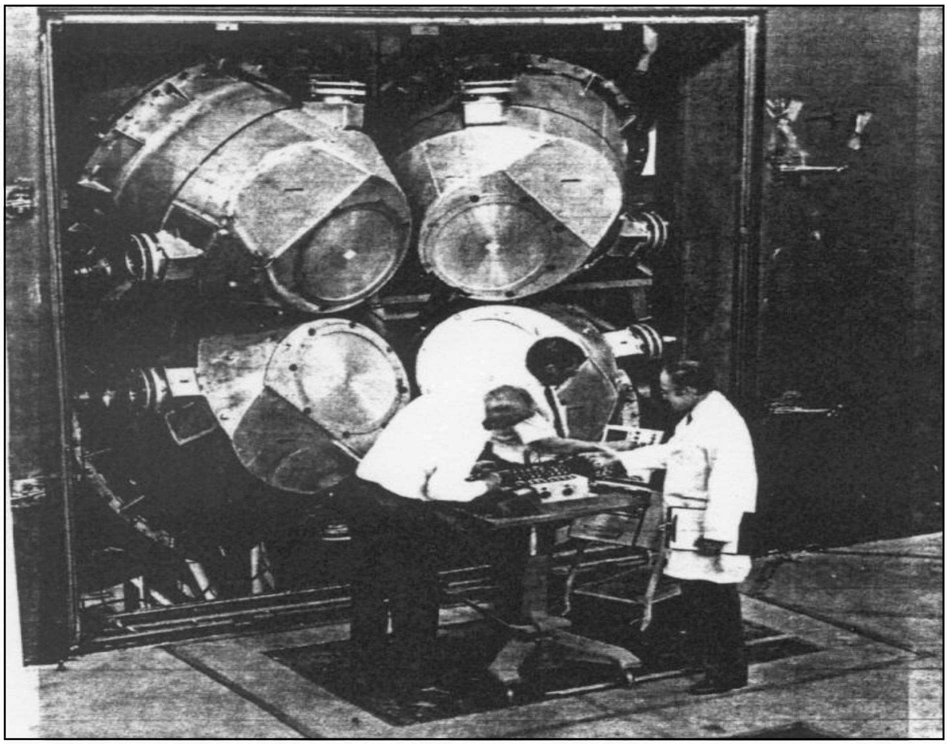


S-1000 Observation Bunker.

Army Involvement in Pacific and National Test Site Nuclear Tests
The Contribution of the Harry Diamond Laboratory

Robert A. Pfeffer, Physical Scientist
Francis N. Wimenitz, Retired

The two-fold purpose of early U.S. nuclear tests is well known: (1) resolve several weapons phenomenology questions, and (2) identify equipment susceptibility. However, few people realize the significant technical contributions made by Army scientists and engineers in support of those tests. This article addresses contributions by the technical staff of the Harry Diamond Laboratory (HDL). It emphasizes the specific Army reasons for their participation, the Army staff members of note, and their contributions to the understanding of weapons phenomenology and equipment susceptibility. Future articles will identify contributions made by the staffs of the Ballistics Research Laboratory, Fort Monmouth and the White Sands Missile Range.



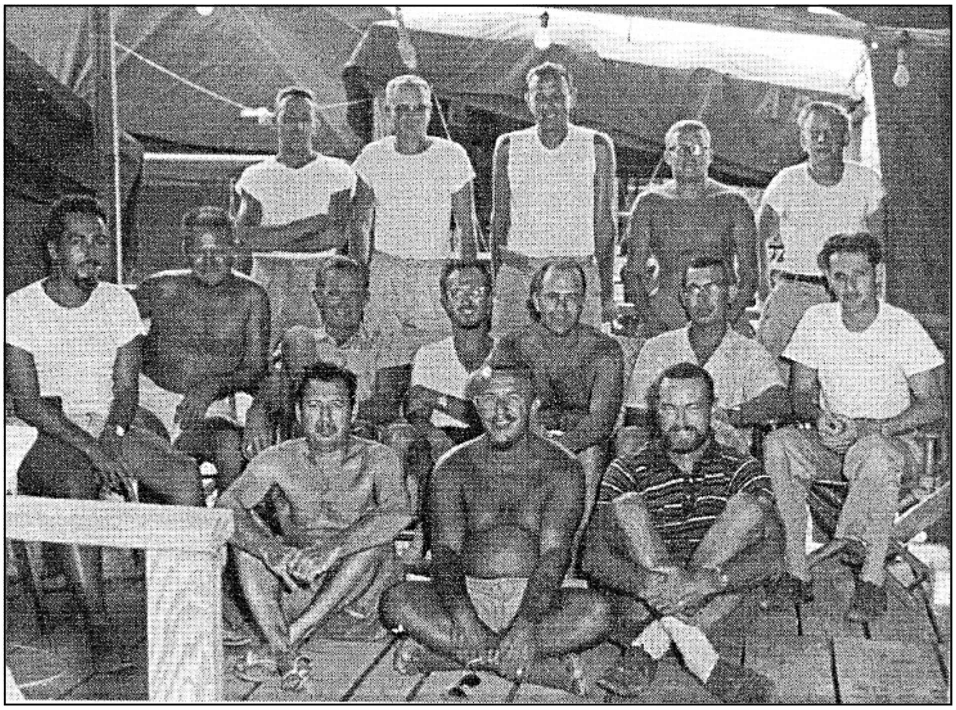
HDL Scientists Setting an Experiment at the Position of Maximum Radiation Exposure in Front of Four Beam Tubes of the Aurora Facility.

Several excellent unclassified websites (some of which are listed at the end of the article) provide general information on the U.S. nuclear test program, including excellent color photos of the shots.

Atmospheric Nuclear Tests and Simulation 1957-1962

HDL participation in early nuclear weapons tests actually began with the establishment of its predecessor, the Diamond Ordnance Fuze Laboratories (DOFL). DOFL history began on November 29, 1940, when the National Defense Research Committee (NDRC) authorized the transfer of $20,000 to the National Bureau of Standards (NBS) (now the National Institute of Science and Technology) "…for the development of certain new and secret devices". The devices were proximity fuses for Army weapons delivery systems, i.e., non-rotating projectiles like bombs, rockets, and mortar shells, and for Navy rotating projectiles, such as antiaircraft and artillery shells. The task rapidly grew, and in July 1953 as part of the resolution of a bitter controversy over the testing of a battery additive, AD-X2 (Figure 1), Sinclair Weeks, the Secretary of Commerce, forced the resignation of the NBS Director, Dr. Allen V. Astin. His resignation resulted in a massive outpouring of concern and support from the scientific and technology communities. To help resolve the issue, Secretary Weeks requested the heads of seven technology and scientific societies to appoint/form a committee that would evaluate the NBS functions. Dr. M. J. Kelly, President of the Bell Telephone Laboratories and a member of the National Academy of Science, was appointed to head the new committee. On July 1953, as part of the committee's recommendation Mr. Weeks and Mr. Charles E. Wilson, in a joint statement, announced that the four ordnance research and development divisions at the Bureau of Standards would be transferred to the Department of Defense, and named the Diamond Ordnance Fuze Laboratory. In a separate action Dr. Astin was reinstated as the NBS Director.

Almost immediately, DOFL scientists began investigating the response of mine fuses to various effects, in-



HARDTACK test team
Front Row, from left: M. Barcanic, R. Rourke, B. Lackey
Middle Row, from left: F. Wimenitz, J. Whetley, R. Stroupe, R. Puttcamp, E. Conrad, R. Tucker, A. Hill
Back Row, from left: W. Behrens, A. Ward, Unknown, S. Gordon, E. Ellsworth

cluding seismic vibrations, pressure, reflected nuclear radiation, and magnetic fields. Peter H. Haas (who later became the first Defense Nuclear Agency (DNA) Deputy Director (Science and Technology), 1974-1979) quickly focused on the effect of what is now called electromagnetic pulse (EMP), and by 1956 he had assembled a team of scientists that were investigating EMP and nuclear radiation effects on mine fuzes. Two of these scientists, Paul Caldwell and John Tompkins, previously worked on the Manhattan Project.

OPERATION PLUMBBOB became the first series of interest to DOFL. Of the 29 planned shots between May-September 1957, six were selected by Peter Haas to include Army tests. He chose them in part because they were low-yield. His interest was to measure the magnetic fields near each shot. These near fields are very complex and are in the presence of time-varying air conductivity. He is credited with having made the first validated magnetic near-field measurements. Major contributors to those Army tests included Bob Puttcamp and Frank Wimenitz. In addition, these measurements were made to record the effects of radiation on electronic components. Warren Behrens and John Schaull led this study. Preliminary tests were done in 1956 at the Los Alamos Scientific Laboratory using the Godiva pulse reactor as a neutron source. The PLUMBBOB results and the Godiva results were entirely consistent for the 293 transistors and 60 semiconductor diodes tested. From these tests, DOFL developed some of the first radiation hardening procedures for military electronic equipment. One important conclusion was that well-designed electronic equipment would survive neutron fluences that were higher than levels fatal to man. This conclusion helped confirm that man is the weak link in most systems and it influenced the decision to balance Army equipment survivability levels to those of man. This balanced hardening approach is a procedure still followed by the U.S. Army Nuclear and Chemical Agency when they establish hardening criteria for manned Army platforms and systems supporting critical missions.

Even while PLUMBBOB tests were being prepared, plans for another series of tests called OPERATION HARDTACK were initiated. These shots were to be held at the Bikini Atoll in the Pacific Ocean between May and August 1958. Pete decided to enlarge his staff to address both critical tactical and strategic Army systems. By this time, about 16 scientists were working on nuclear weapons effects and their effects on systems. Ed Conrad (who became DNA Deputy Director (Science and Technology), 1979-1983) was chosen to lead the Army HARDTACK test team.

OPERATION HARDTACK results were less successful than OPERATION PLUMBBOB results. Transient response data proved less reliable than the PLUMBBOB static measurements of Behrens and Schaull. In addition, Godiva tests tended to show more damage to PLUMBBOB-tested devices. Nevertheless, Army scientists found a sufficient spread in radiation damage to semiconductors that they proposed using harder technology semiconductors to increase electronic systems survivability, another procedure still followed today.

As valuable as the nuclear test results were, by 1958 it was becoming increasingly clear that laboratory simulators, even with their limitations, would provide a better controlled and more accessible environment in which to conduct radiation and EMP studies. In addition, the U.S. had unilaterally suspended nuclear weapon testing. Planning for DOFL's two new simulators started immediately.

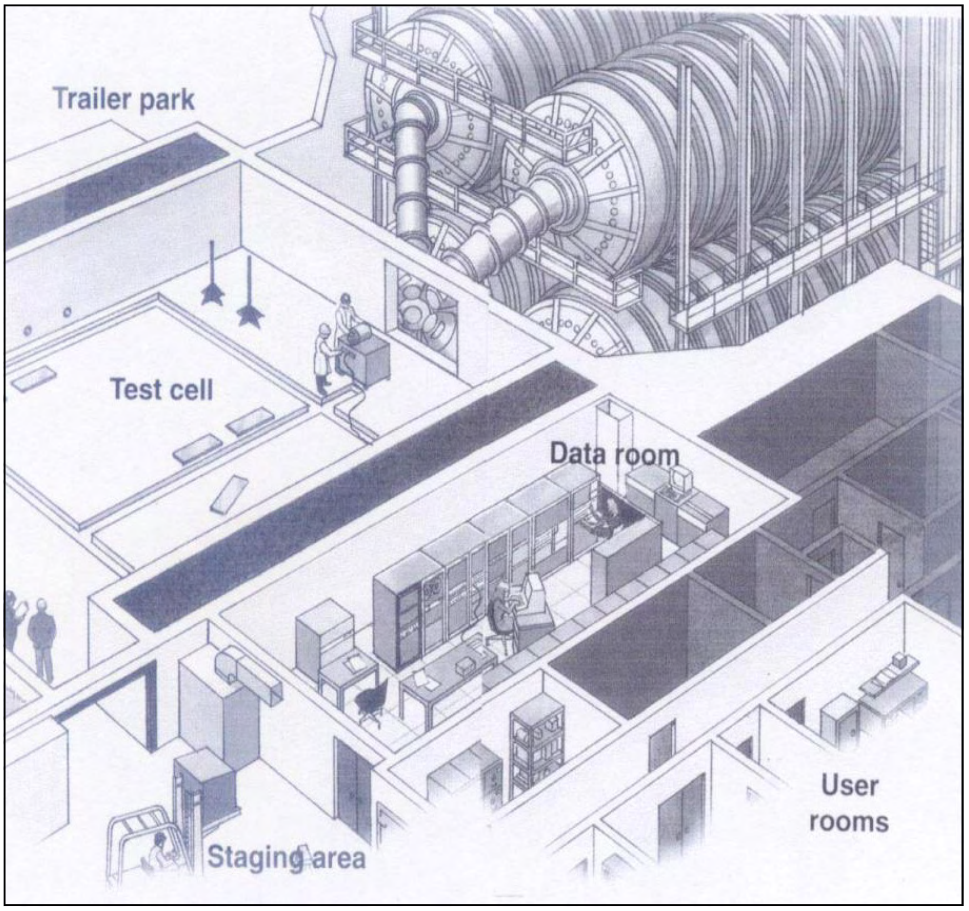
Diamond Ordnance Radiation Facility (DORF)

The Diamond Ordnance Radiation Facility (DORF) was located on the grounds of the Forest Glen annex of the Walter Reed Army Medical Center

in nearby Maryland. The reactor was to be used to study the effects of nuclear radiation on Ordnance electronics and for medical research and biological studies. It was designed around a modified TRIGA Mark F swimming pool, pulsable reactor that was housed in a windowless building specially designed to eliminate the possibility of radiological hazard while still meeting the experimental requirements for both electronic and biological studies. The reactor core was suspended from a movable carriage and was located near the bottom of a 20-foot deep aluminum, water-filled tank. The core had 87 stainless steel clad uranium/zirconium hydride fuel and moderator elements in a cylindrical array. Radiation from the core was obtained either in a large, dry, heavily shielded fast neutron exposure room or in radiation positions within the core or the pool.

The reactor could be operated in one of three modes: 2000 megawatts (MW) peak power pulse; 100 kilowatt (kW) steady state, or 250 kW square wave. Its safety and pulsing characteristics were the result of a unique, inherent, extremely large self-regulating negative temperature coefficient of reactivity. This was a property of its uranium and zirconium hydride fuel elements and allowed the reactor to be made supercritical for an instant, causing its temperature and power to rise to a peak of about 2000 MW in a few milliseconds, after which it quickly and automatically shut itself down, without relying on control rods or other mechanical devices.

In order to gain experience in using the TRIGA reactor, to observe its operation, and to further its research program, DOFL began conducting radiation effects experiments and tests at the La Jolla TRIGA in April 1959, where the early experiments were conducted on vacuum tubes, gas thyratrons and semiconductors similar to those tested in HARDTACK and PLUMBBOB. The purpose was to study them under better-controlled laboratory conditions. The tests were later extended to include a wide variety of transistors, electronic components, circuits and systems. The La Jolla tests continued, on an approximate bimonthly schedule, for almost two years. The tests provided excellent experimental experience, very useful radiation effects information, particularly in relation to semiconductor devices, and valuable knowledge of the operations of the TRIGA. By 1961 DOFL had completed testing at General Atomic and on 17 October the DORF was dedicated.



Artist Conception of the Aurora Facility.

High Intensity Flash X-Ray Facility (HIFX)

1961 also saw the installation of the High Intensity Flash X-Ray (HIFX) at DOFL. The HIFX source consisted of a pressure vessel containing a gas dielectric, a Van de Graaff generator that was fed through a high voltage coaxial line structure to a 12 inch single point field emission tube. The generator was mounted horizontally and could produce either photons or an electron beam in a 12x14x12 ft. exposure room. X-rays were produced by electrons striking a tantalum target at the tube face. Exposure could be controlled by varying either the charging voltage or by varying the distance from the tube face. For thermomechanical studies, the electron beam was extracted through a thin window and the energy deposited in the test object.

HIFX was the “work horse” of the DOFL radiation program. It was used extensively to investigate transient radiation effects in electronic components. In addition, it provided the source for early thermomechanical damage tests of semiconductor components and the source for the study and development of radiation detectors.

A much larger extra-high intensity flash x-ray facility (AURORA) was initiated in December 1969 and completed in April 1972 on the HDL facility in Adelphi, MD.

SMALL BOY Crew.
Front Row, from left: T. Hannold, F. Wimenitz, J. Turner, W.Johnson, J. Verrill, A. Hill, A. Shubart, S. Marcus
Back Row, from left: R. Wheatley, P. Caldwell, D. Worcester, M. Morgan, W. Seachrist, R. Burton, H. Eisen, S. Moss, R. Ulf, R. Puttcamp, P.H. Hass, M. Bishop

The Last of the HDL Atmospheric Tests

By mid-1961 test ban negotiations between the Soviets and the new Kennedy administration had become stalemated by the issue of a Soviet veto. Despite all efforts by the U.S., the Soviets appeared to be in no mood to compromise. Khruschev downplayed the importance of a test ban and on several occasions hinted that the Soviets might resume their own tests. On 1 September they detonated a nuclear weapon in the atmosphere. By 15 September the U.S. started to test nuclear weapons underground and on 25 April atmospheric testing was resumed in the Pacific with Operation Dominic on Christmas Island.

At this time the DOD was beginning to consider ground burst EMP as a major threat to certain military systems. The Army was also concerned for the survival of its strategic and battlefield systems to EMP effects. Little was known about the near-field EMP phenomenon, since few specific measurements of close-in fields and gamma time-histories had been obtained. The PLUMBBOB results constituted the only available near-field data and the prevailing EMP theories and analytic tools were inadequate to predict, with any degree of confidence, the threat conditions. To correct this situation the Defense Atomic Support Agency (DASA) planned the SUN BEAM series of atmospheric tests, which was conceived as a series of nuclear events designed to provide the necessary EMP information and data to develop an improved prediction capability. The SMALL BOY event was the first in the series.

SMALL BOY, July 1962

The SMALL BOY event was planned to define EMP phenomenology and effects more comprehensively. DOFL participated with three projects; gamma and neutron dose rate measurements to provide information on the radiation pulses that interacted with the atmosphere to generate the EMP, and magnetic loop measurements to measure the close-in EMP magnetic field. SMALL BOY was fired on 14 July 1962.

Radiation Measurements

The radiation project had its share of data loss. In many cases, poor quality oscilloscope traces were saved by a specially developed technique to intensify them. In spite of these difficulties nearly complete gamma and neutron data were obtained.

Magnetic Field Measurements

The magnetic field measurement project also had its share of data loss but the azimuthal field measured at the earth's surface was consistent with measurements made by other projects and with the prevailing theories of Dr. Conrad Longmire. At two locations the shape of the magnetic field and the local gamma pulse were in good agreement for times greater than about 10 microseconds. This led to the postulation of a new EMP source, the ground gamma rays. At the 100-foot depth station, measurements were in good agreement with calculations made by John Malik of Los Alamos and D.F. Fisher of GE Tempo, Santa Barbara.

Underground Nuclear Weapon Tests

Following SMALL BOY three events changed the focus of the DOFL program: the Cuban missile crisis brought the reality of a nuclear war into sharp focus and boosted the interest of the military in the nuclear survivability of strategic weapon systems; the cessation of atmospheric nuclear weapon tests in late 1962, and the signing of the Limited Test Ban Treaty in August 1963 which prohibited all but underground nuclear tests. This obliged the DOD to find other sources of radiation to satisfy the mounting pressure from the military to validate the hardening of U.S. strategic weapon systems.

For this DASA turned to the vertical line-of-sight (LOS) underground nuclear test. To assist DASA, the Office Chief of Research and Development, established that the Harry Diamond Laboratories would provide Technical Directors for the nuclear tests that were to be conducted at the Nevada Test Site.

In a LOS test, an evacuated pipe

that runs from the device, buried deep underground, to the surface, provides a channel for the nuclear radiation emitted by a nuclear device. The pipe included a variety of closure devices designed to contain the radioactive fission products, weapon debris, and gases created by the explosion before they could escape to the atmosphere.

The experiments were placed on a multi-layered tower positioned to be directly in the beam of radiation coming up from the nuclear device. The responses of the experiments were monitored during and after the exposure by recording equipment located in instrument trailers parked about 750 feet from the tower. In executing an underground nuclear weapon test the Test Director (TD) was responsible for the development of the overall experimental program. The TD was then responsible for assuring the success of the experiments in the field, and upon completion of the test, for approving all the experiment reports, and for writing a summary report that included appropriate conclusions and recommendations for future tests.

During the period from Feb. 1965 to Sep. 1969 HDL provided technical directors for six vertical LOS tests.

18 February 1965 – WISHBONE, Peter H. Haas

16 June 1965 - DILUTED WATERS, Francis N. Wimenitz

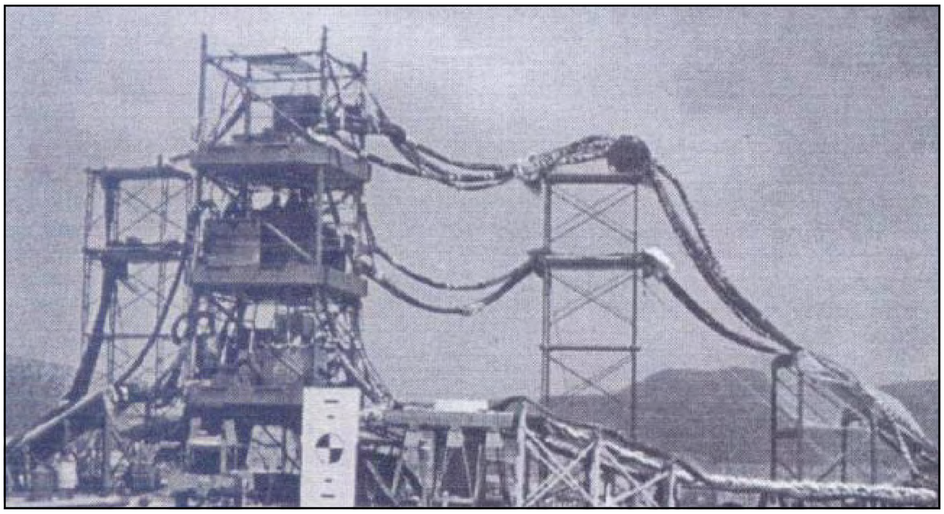
25 April 1966 - PINSTRIPE, Edward E. Conrad

13 December1966 - NEWPOINT, Robert E. McCoskey

25 March1968 - MILKSHAKE, Paul A. Caldwell

12 September1969 - MINUTE STEAK, Paul A. Trimmer

As attention shifted to the survivability of strategic systems, HDL focused on two effects that were becoming the major concerns for Army strategic missile systems: Thermomechanical Shock (TMS) and Internal EMP (IEMP).

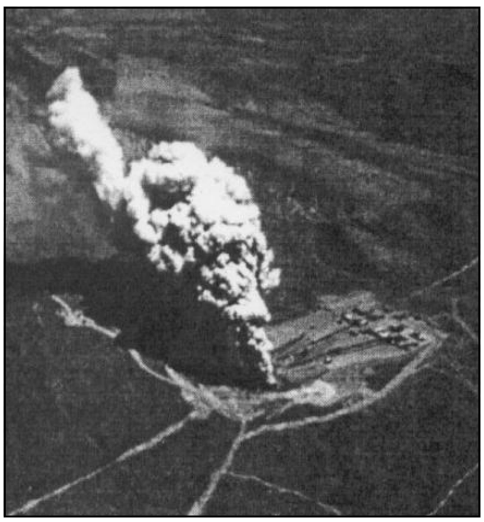


PINSTRIPE Tower Showing Cables and Supports.

Thermomechanical Effects

When a missile is exposed to a nuclear weapon that emits high energy x-rays, the amount of energy transmitted to the electronic material within the missile system is greatly increased and shock waves are produced that propagate through the material and can cause a variety of catastrophic damage.

In 1964, studies revealed that semiconductor devices were the most susceptible. The results of early tests indicated that catastrophic failure resulted primarily from the mechanical failure of bonded surfaces between high and low atomic number (Z) materials, the metal interconnects burnout, and the silicon substrate fracture. Since these materials were present in almost all contemporary semiconductor devices, these components were established as the weak link in missile and satellite systems.



PINSTRIPE Shortly After Detonation.

Contemporary semiconductor components were manufactured using procedures that had some degree of random variation. This resulted in bonds and elements whose strength was not unique but was generally described by a statistical distribution. The scope of the problem was then expanded to include not only the determination and understanding of the modes of catastrophic failure produced but also the probability of failure and the role which production quality control played in determining the observed failure rate.

HDL and other laboratories, with DASA support, began to investigate, in detail, the problem. At the request of DASA, Ed Conrad directed the HDL TMS program with the assistance of Bob Oswald for in-house research. In addition, Texas Instruments, Fairchild Semiconductor, and Motorola were recruited to develop hardened components.

In 1967, Dr. Robert Oswald set about to investigate and characterize the modes of failure produced in various types of transistors exposed to electron beams. In this effort Dr. Oswald pioneered the application of laser interferometry to the measurement of the mechanical properties and the response of materials to pulsed electron beam exposure. These meas-

urements allowed the thermoelastic properties of the material to be determined directly. They were then used as the source of data for the generation of computer models used to predict the response of materials in a nuclear environment.

A solution to the x-ray problem was not easy to find. Shielding the components to reduce the x-ray exposure was not practical. The added weight of the shielding required an increase in boost capacity or resulted in an unacceptable reduction of payload or missile range. Screening contemporary devices to select survivors was not very successful. The failure of the screening technique led to a concentration on developing inherently harder devices.

HDL embarked on a broad program to develop highly reliable, low-Z devices and to examine the underlying physics of the TMS phenomenon more closely. The results of this program are felt today.

Internal EMP (IEMP) Effects

In early 1965 the interest of John Tompkins and his group at HDL was piqued by a report by Dr. Andrew Sessler of the Lawrence Livermore Laboratory that predicted the possibility of significant electromagnetic effects that resulted from the effects of emitted photoelectrons and Compton electrons in cavities, circuit boxes and missile interior spaces where it appeared that substantial cable current transients might be generated. It was thought possible that if a system were flying sufficiently high when exposed to the high energy x-ray output of a nuclear weapon, it might then see very large internal photoelectron currents as well as lower magnitude gamma-ray generated Compton-electron currents. The phenomenon became known as Internal Electromagnetic Pulse (IEMP) and later alternatively as System Generated Electromagnetic Pulse (SGEMP).

Tompkins, Rosado and Vault were convinced of the potential threat to missile systems. They argued that strategic missiles in the upper-altitude phases of their flight were susceptible to the production of IEMP as a result of direct irradiation from a nuclear burst. Their calculations indicated that IEMP field strengths inside such missiles could be orders of magnitude greater than the fields from an externally incident EMP.

They immediately began a theoretical and laboratory investigation with a view to early participation in an underground x-ray test. Laboratory techniques were developed to simulate the response of electronic systems to IEMP by injecting currents into cavities to simulate the skin current created by electrons ejected from interior surfaces by radiation. Using these techniques, good agreement with radiation test results was obtained.

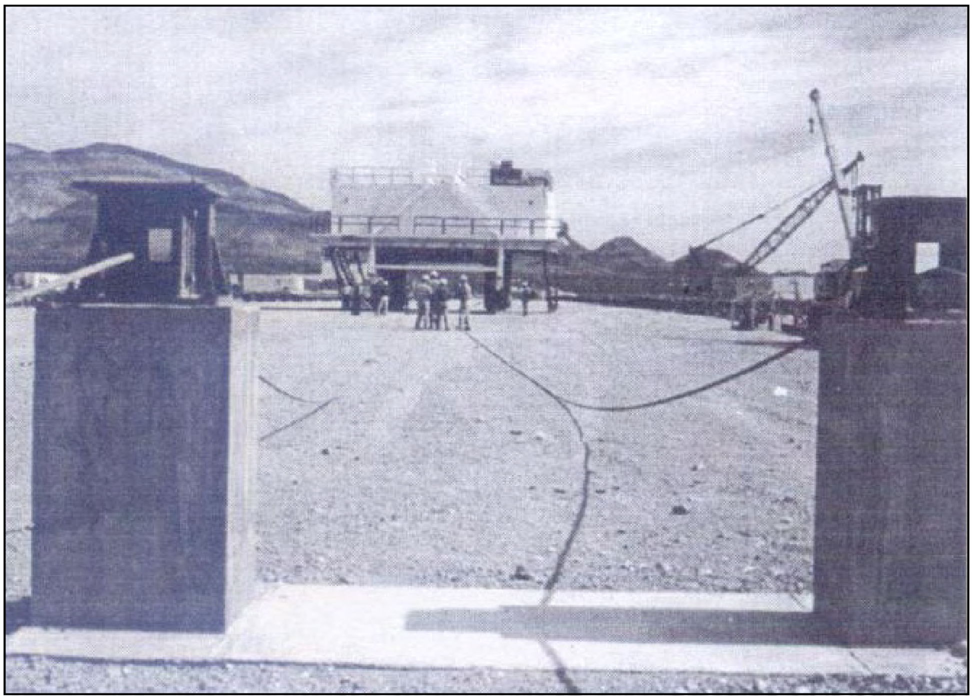
As a result of the early work by Tompkins, Rosado, Vault and Gilbert, and particularly the MILK SHAKE underground weapon test, the Air Force and the Army became more acutely aware of the IEMP threat to their strategic missile systems.

MILK SHAKE, March 1968

The MILK SHAKE IEMP experiment was the first test conducted by the HDL group in a nuclear test environment. The experiment was designed to measure the photoelectric current generated inside a simple container subjected to x-ray and gamma radiation. These currents served as a source of IEMP fields. The first objective was to measure the net current flowing in evacuated and air-filled enclosures when subjected to radiation from a nuclear weapon and the second objective was to determine the effect of space charge limiting.

For the experiment, parallel plate geometry was chosen. To control the effective capacitance between the plates and to minimize the effects of the limited size of the detector, a cup-shaped collector was used rather than a flat plate. Three diode-type detectors were employed to measure the net current under evacuated and air-filled conditions and to observe the space-charge limiting phenomenon.

Signals attributed to the x-ray pulse were generated in both the evacuated and the air-filled enclosures. Space charge limiting was observed and the test confirmed the predictions of the current ejected from the walls of a container.



Front View, MINUTE STEAK Test Tower.

Space charge limiting and air conductivity reduced the magnitude of the collected current but still allowed enough to flow that could present a threat to missiles operating in the exoatmosphere.

Encouraged by the success of the MILK SHAKE results, Tomkins and Rosado decided to test their results using the more complicated configuration of a scaled Spartan missile section on the MINUTE STEAK event.

MINUTE STEAK September 1969

The objective of the HDL MINUTE STEAK IEMP experiment was to measure the currents in the principal cables and the internal magnetic field in a half-scale mockup of a Spartan missile section. A second objective was to measure the photo and Compton electron densities emitted from both shielded and unshielded sections of the missile skin.

The model was evacuated to the low ambient pressure at the proposed operating altitude, and contained an actual Spartan wiring harness and mockups of system component boxes. The MINUTE STEAK data revealed large current densities in the model section and large voltages on many of the harness wires. Data was obtained on the air pressure dependence of the EM field and the type of material and arrangement of cables. It was becoming very apparent that IEMP could be a serious threat to missile systems and needed further investigation.

DIAGONAL LINE, November 1971

DIAGONAL LINE was principally a hot x-ray test to verify the satisfactory performance of a part of a Navy strategic missile electronics system but it also supported a variety of advanced technology experiments that included TMS and the HDL IEMP phenomenology study.

IEMP Experiment

Raine Gilbert, John Rosado, John Tompkins and several members of the HDL staff conducted the HDL IEMP experiment. It was a continuation of their IEMP phenomenology studies and tests of the Spartan system.

Data obtained on the MILK SHAKE and MINUTE STEAK events made it advisable to proceed with more realistic test configurations to assess more accurately system susceptibilities in a high-altitude x-ray environment. This led to the DIAGONAL LINE test where a full-scale portion of the Spartan missile system was exposed at the operational internal pressure. The model contained detailed wiring harnesses and many actual system components. The primary objective was to bound the prediction capability of IEMP phenomena by measuring the fields and cable responses and correlating them to predictions based on theory and laboratory simulation of the expected environment. A secondary objective of DIAGONAL LINE was to test newly developed IEMP sensors, and to improve the understanding and application of some accepted theories.

The results were very gratifying. The calculations and measurements of expected electrical potential agreed within 5 percent. The expected enhancement of the magnetic field and coupled current due to space charge barrier breakdown was observed only in portions of the model, but the predictions of IEMP coupling were in remarkably good agreement with the measurements.

The experiment provided considerable insight into the generation and coupling of IEMP within a realistic system configuration and generated greater confidence in current injection and flash x-ray simulation testing on which DIAGONAL LINE predictions were based. It also verified the potential threat to a very important U.S. strategic system.

The Harry Diamond Laboratories was a pioneer in nuclear weapons effects research and testing. Through their nuclear weapon testing, they made important and long-lasting contributions to the basic knowledge of nuclear weapon phenomena and to the technologies used to assess the vulnerability and hardening of the weapon systems.

Further Reading

Most of the historical information and all of the figures were obtained from a combination of private conversations with, and an excellent unpublished draft by, Mr. Francis N. Wiminitz, entitled History of HDL Nuclear Weapon Testing 1954-1971. Supporting information was also provided by Dr. Ed Conrad. Names were included in the article to allow the reader to further review their technical work.

http://nuclearweaponarchive.org/Usa/Tests/Plumbob.html

http://www.atomicarchive.com/Photos/LANL/Hardtack_2.shtml

Francis N. Wimenitz is a physicist with an B.A. and M.A. from Temple University in Philadelphia, PA. For over 40 years, he was actively involved in the nuclear program of the Department of Defense, specifically studying radiation and electromagnetic effects. Mr. Wimenitz worked for Harry Diamond Labs from 1953 to 1981.

Mr. Robert A. Pfeffer is a Physical Scientist at the United States Army Nuclear and Chemical Agency in Springfield, VA, working on nuclear weapons effects. He has a B.S. in Physics from Trinity University and an M.A. in Physics from The Johns Hopkins University. Previous government experience includes Chief of the Harry Diamond Laboratory (HDL) Electromagnetics Laboratory and Chief of the 400-acre Woodbridge Research Facility, both in Woodbridge, VA.

Why MAD was Insane

Michael F. Altfeld, Ph.D. Strategic Nuclear Forces Analyst
U.S. Army Staff, DAMO-SSD

My, my, how soon we forget. It has only been 14 years and some months since the demise of the Soviet Union and already some analysts seem to be unable to remember the massive amount of intellectual effort that went into demonstrating that Mutual Assured Destruction (MAD), more accurately referred to as "Mutual Vulnerability," was an approach to nuclear weapons that was, at the same time, both morally and strategically indefensible. Thus, what is immediately interesting about MAJ Pache's article (please see *NBC Report Fall/Winter 2005* page 46) is that it demonstrates the indefensibility of MAD by not fulfilling the promise made to readers in the title. His article never demonstrates "Why MAD was Sane" why it was a rational, reasonable policy choice when other choices were available. Rather, it asserts that there really was no other choice, that "Technology would… drive the focus of nuclear policy on both sides of the Atlantic." [1] If there is no choice, the outcome cannot be "sane" or "insane," it is just a fact of life. [2] However, using the argument that "MAD is a fact of life" to hide the existence of real policy choices from the people must be seen as bordering on the criminal, especially since MAD itself constitutes the crime of intentionally murdering masses of civilians. [3]

Massive Retaliation.

I will have much more to say about MAD later. Before doing so, however, I must correct several misconceptions regarding the misnamed "Massive Retaliation" strategy. First, while the wide-spread myth is that the strategy enunciated by Foster Dulles in his speech of January 12, 1954 was to respond to virtually any Communist advance with a large-scale nuclear attack, this was far from the truth. The fact is that, in his speech, and in the "clarifying article" he later wrote in *Foreign Affairs*, Foster Dulles made it eminently clear that he was articulating a strategy of "selective retaliation." with "massive retaliation" being only the most extreme option. [4] Indeed, he allowed that local defenses would always be necessary and, as he stated in his *Foreign Affairs* article, there was no reason to believe that a local conflict necessarily "…would be turned into a general war with atomic bombs being dropped all over the map." [5]

Second, Foster Dulles was also quite aware that the strategy of "massive retaliation" (so-called) might have a limited lifespan. As he wrote in his *Foreign Affairs* article, "But such power [strategic air power], while now a dominant factor, may not have the same significance forever. Furthermore, massive thermonuclear retaliation is not the kind of power which could most usefully be invoked under all circumstances." [6] Indeed, the Eisenhower Administration, took a number of steps to meet Soviet nuclear developments so as to extend the lifespan of the "massive retaliation" strategy. These steps included the building of early warning systems such as the DEW Line, which was completed in July, 1957, as well as the enhancement of U.S. air defenses through the deployment of the NIKE missile system. Finally, it is not the case that the military had doubts about the willingness of their civilian masters to release nuclear weapons when the time came (at least, under Eisenhower). NSC 162/2, dated October 30, 1953 stated, among other things, that, "In the event of hostilities, the United States will consider nuclear weapons to be as available for use as other munitions." [7] Further, in December of 1953, the Chairman of the Joint Chiefs, far from expressing doubts, stated that "Today, atomic weapons have virtually achieved a conventional status within our armed forces." and Ike himself, in a Press Conference held in March, 1955, stated that "Where these things [nuclear weapons] are used on *strictly military targets and for strictly military purposes*, I see no reason why they shouldn't be used just exactly as you would use a bullet or anything else." [8] (emphasis added). Indeed, the only organization within DOD that appeared to oppose the "conventionalization" of (tactical and strategic) nuclear weapons was the U.S. Army. Its opposition, however, can be seen as at least somewhat self-serving in that, had nuclear weapons not been integrated into the U.S. armed forces, the Army would have had to be greatly enlarged in order to put enough troops into Europe to meet the 96 division requirement laid out in the "Lisbon Force Goals" to hold off a Red Army estimated at between140 and 175 divisions. Since the U.S. economy was judged by Eisenhower to be unable to bear the burden of the increase to 96 divisions from the 25 divisions then fielded by NATO, it seemed natural to take the less expensive route of simply making those 25 divisions far more lethal by arming

them with tactical (and later Theater) nuclear weapons, and backing them up with strategic nuclear weapons. [9]

To conclude, what I hope to have shown in this brief discussion of the so-called "Massive Retaliation" strategy, was that it was no such thing. Those who believe that it was; that it was the simplistic concept of responding to the most limited Communist provocation with large-scale nuclear strikes without nuance or flexibility, are simply wrong. I will now go on to correct some serious misconceptions regarding MAD.

Mutual Assured Destruction.

One myth regarding MAD is that it was, as MAJ Pache stated, forced by technology; that there was no choice. However, that is not empirically true. When Robert McNamara first stepped into the role of SECDEF, he did not advocate anything close to MAD, which he seemed to feel was, as I expressed above, both morally and strategically indefensible. Rather, he advocated what was called "No Cities Counterforce." But let us allow Mr. McNamara himself to explain what is meant by this term. At his Commencement Address at the University of Michigan given in 1962, he stated that:

> *…principal military objectives, in the event of a nuclear war stemming from a major attack on the Alliance [NATO], should be the destruction of the enemy's military forces, not of his civilian population…We are giving a possible opponent the strongest imaginable incentive to refrain from striking our own cities.* [10]

Earlier, at a SECRET NATO Seminar in Athens, McNamara had stated that "…our studies indicate that a strategy which targets nuclear forces only against cities or a mixture of civil and military targets has serious limitations for the purpose of deterrence and for the conduct of general nuclear war. [11]

The strategic logic behind No-Cities Counterforce was stated best (as one might expect) by the Air Force. In a U.S. Air Force publication titled *This is Counterforce*, dated February 7, 1963, it was argued that:

> *While a potential aggressor might have cause to question the credibility of a strategy that depends on a "city-busting" retaliatory response, he should have no doubts about the credibility of a strategy based on the ability based to destroy his remaining military forces and eventually prevail. The loss of these forces is one risk he cannot afford to take, for once deprived of his military strength he is compelled to accept peace on our terms.*

It should be clear by now that McNamara himself not only did not come into office espousing MAD, he came into office espousing its exact opposite. Interestingly enough, this placed McNamara in rough agreement with Eisenhower's policy on nuclear use, expressed in the press conference cited above. Further, it was relatively easy for McNamara to embrace "No-Cities Counterforce" at the time, because the U.S., under Eisenhower, had built up a very high level of nuclear superiority (or, "escalation dominance") over the Soviets, which is exactly what "Massive Retaliation" requires for successful deterrence. Indeed, in October, 1961, during the Berlin Crisis, then DEPSECDEF Roswell Gilpatric publicly informed the Soviets (and the rest of the world) that we not only possessed "tens of thousands" of nuclear delivery vehicles, but that we also possessed escalation dominance over the Soviet Union (a fact we had confirmed through the Corona program) and that, by implication, any attempt by them to escalate to nuclear war over Berlin by a first strike against the U.S. would not only do themselves no good, it would actually leave them worse off than before they had struck the U.S. As Gilpatric stated:

> *The destructive power which the United States could bring to bear even after a Soviet surprise attack upon our forces would be as great as – perhaps greater than – the total undamaged forces which the enemy can threaten to launch against the United States in a first strike. In short, we have a second strike capability which is at least as extensive as what the Soviets can deliver by striking first. (emphasis added).* [12]

From both a moral and strategic point of view, No-Cities Counterforce/ escalation dominance was the correct strategy. It attempted to minimize enemy civilian casualties, as called for in the law of war and Just War theory, rather than commit a war crime by specifically targeting them. Further, it did not require the cooperation of the enemy to work. Certainly, the Soviets could still attack U.S. civilian targets if they wished to, but only at the cost of seeing their own cities destroyed in return. More importantly, however, McNamara's initial view that "…to the extent feasible, basic military strategy in general nuclear war should be approached in much the same way that more conventional military operations have been regarded in the past," meant that defenses against ballistic missiles would be deployed as soon as they were feasible, even if they had to rely on low-yield nuclear warheads to be effective. After all, a very low-yield detonation at, say, 100,000 feet is far preferable to a, say, 500 Kt detonation on the surface of the United States. [13] And, even reasonably effective defenses would make it extremely difficult for an enemy to contemplate a large-scale attack on the U.S. [14]

The need to create and maintain the situation of U.S. escalation dominance over the Soviets was not cheap, however, especially as Soviet strategic forces became more numerous and more capable. McNamara explained this at a House Armed Services Committee Hearing at which he stated that the U.S. needed a force that was not only invulnerable, but also "larger than would otherwise be the case. Because since no force can be completely invulnerable, we will lose a portion of it under those cir-

cumstances [a Soviet counterforce first strike] and we must buy more than we otherwise would buy." [15]

Thus, by the early '60s, McNamara seemed to have become devoted to counterforce and escalation dominance as the best means of deterrence, and was willing to pay the price to achieve it. Yet, only a few years later, he would change his mind completely and adopt what amounted to a strategy of mass-murder and suicide: Assured Destruction. In his February 18, 1965 budget statement for FY06, McNamara stated that:

> *A vital first objective, to be met in full by our strategic nuclear forces, is the capability for Assured Destruction…the destruction of, say, one-quarter to one-third of its population and about two-thirds of its industrial capacity…would certainly represent intolerable punishment to any industrialized nation and thus should serve as an effective deterrent*. [16]

There are numerous questions which this massive change of mind and heart on McNamara's part raises. I shall try to deal with those most relevant to the topic. First, many people feel that we were forced into a posture of Assured Destruction (AD) by "technology." However, advancing technology, per se, only made counterforce strikes with limited collateral damage more feasible. It did this by increasing the accuracy of warheads (which allowed target destruction with lower yields), and enabling the development of Multiple Independently Targetable Re-entry Vehicles (MIRVs), which allowed a single missle to carry several warheads. So, technology, per se, does not appear to be the culprit here. Rather, it appears that, in the end, the price of maintaining escalation dominance got too high for the Johnson Administration. Thus, McNamara used AD, at least in part, as a device to demonstrate that a sufficiency of forces existed and that no further build-up was necessary. [17]

Second, did McNamara really believe in AD or was it just a "force sizing tool?" There are those who claim that the target list was never altered under Johnson and, unfortunately, that claim cannot be debated in public. However, what is obvious is what weapons were procured to support our policy. The largest single type of weapon, in terms of numbers, produced in the late '60s was the Poseidon warhead. According to the International Institute of Strategic Studies' *The Military Balance: 1991-92*, p. 221, that warhead had a yield of only 40Kt. And a CEP of only around 1400 feet. If these numbers are anywhere close to the truth, such a warhead would have almost zero probability of destroying a heavily hardened silo, But, it would make a great city killer, especially given the number of such small warheads that could be carried on each Poseidon missile. [18]

Third, there is the question of just what can be deterred with the threat of mass murder? Certainly, an all-out attack on America's cities and civilian population could likely be deterred by such a counter threat, but what about lesser attacks? In particular, can such a strategy support "Extended Deterrence;" the extension of the deterrence provided by our strategic forces to deter Soviet conventional, or even nuclear, attacks on our European allies? Is the threat of the mass murder of Soviet civilians and the destruction of its industrial infrastructure, which would likely be followed by a similar Soviet attack on the US, be a credible deterrent to a Soviet conventional invasion of Western Europe? The answer on the part of many analysts was "No." Indeed, it was not even clear that, given advances in technology, such a strategy could effectively deter some types of attacks on the US, itself. When James Schlesinger became Secretary of Defense, he ordered a study done to determine the extent of US civilian damage that would be associated with a Soviet attack limited to our deployed nuclear forces. The results of this study showed that an attack limited to bomber bases, missile silos, SSBN ports and key C3 centers would result in approximately 2 million American deaths. 2 million is a large number. But, it is a far cry from the 80 million that would likely die in a dedicated "countervalue" (i.e., mass-murder) strike, should the Soviets choose to launch one. Could our threat to commit mass-murder deter the Soviets from trying to prevent us from doing it in the midst of a severe crisis? Doubtful, I think. [19]

The fourth question raised by the adoption of AD is why in the world the Soviets would buy into it, thus making it *Mutual* Assured Destruction, or MAD, as it ifs popularly, but falsely, known? To do so, the Soviet leadership would have to have had the exact same utility function as the US leadership, especially as regards global issues, but also as regards what deters; i.e., targeting the enemy's civilian population. However, that was clearly not the case. First, according to Soviet Marshal N. Krylov, Commander of the Strategic Rocket Forces (SRF), speaking in 1967, the main objective of any war with the US would be "victory." He also stated that principal targets for the SRF would be "delivery systems, weapons storage, and fabrication sites; military installations; military industries; and centers of politico-military administration, command, and control." And, in case the reader thinks that these are only the words of a Marshal, who would naturally be interested in warfighting as opposed to mass murder, Leonid Brezhnev, himself stated, on the 50th anniversary of the establishment of the Soviet Union, "Let everyone know, that in combat against any aggressor the Soviet country will gain a victory deserving of our great nation…." In February, 1981, he said there would be no victors in a nuclear war, but this statement, made for external consumption, was corrected internally in the same year in an "authoritative" book, *Party Leadership in Military Matters*. [20] In addition, after we and the Soviets signed the ABM Treaty, we ceased all construction and most experimentation on ABM systems. The Soviets, however, built all the ABM capability they were allowed under the Treaty (and, if the Krasnoyarsk radar is any indicator, much that they were not). This is also not the act of someone who has bought into leaving their country vulnerable

to attack. To summarize, quoting Lawrence Freedman:

> *The Russians did not deviate from the traditional view that the role of strategy was to devise means of winning future wars, and that the role of military planners was to prepare the necessary forces. Not only did McNamara fail to convince his Soviet counterparts of the error of their ways but, by emphasizing the possibility of a coincidence of interests between the superpowers in controlling the arms race and avoiding nuclear war, he also neglected the underlying conflict of interests.* [21]

Thus, it seems quite clear that AD was our strategy, but never the Soviet Union's. The Soviets, instead, were attempting to develop a warfighting, war winning capability by combining a counterforce targeting strategy, the weapons to carry it out and ballistic missile defenses. And, for good measure, they developed an extensive civil defense program (which was laughed off in the US, but might well have saved many millions of Soviet citizens' lives had a nuclear war actually been fought with enough warning to implement it). [22]

Why Assured Destruction was Insane.

We have now gone far enough to develop a good idea of why Assured Destruction was, if not insane, at least highly irrational. First of all, it was immoral. Its intended target was the civilian population of the Soviet Union. That alone made it criminal and a direct violation of Just War theory. [23] Second, AD appears, at least initially, to be a strategic choice, made for budgetary reasons, not for strategic or operational ones. Third, to the extent that it was justified as a "strategy" for deterrence, it could, in fact, deter very little. This was because (at the very least for purposes of extended deterrence) on the Soviets accepting our own view of the world and our own view of deterrence theory (i.e., AD). The problem was, they didn't. And, this became more obvious with each passing year as the Soviets built toward their desired war winning capability and our problem of "silo vulnerability" got worse. [24] Finally, and most importantly given actual Soviet objectives, AD depended on the notion that the casualties from any counterforce, or even counternuclear strike being so similar to those associated with a "countervalue" strike that it would justify an AD strike in return. As time went on, this assumption became virtually impossible to defend. Thus, given its nature, AD could only be truly relied on to deter dedicated, large-scale attacks on the US population. It was fairly obvious from the start that extended deterrence could not be supported by such a strategy in theory and, as parity was reached, this became true in practice, as well. Finally, it became questionable whether AD could even deter limited attacks on the US, itself, as the "Schlesinger study" showed.

For at least all of these reasons, Assured Destruction was a strategy that made America immoral and placed the nation at great risk. We were extremely lucky that our opponents in the Kremlin turned out to be as risk averse as they were or we might have found ourselves in the midst of WW III. [25]

Response from the author of "Why MAD Was Sane" MAJ Drew Pache

Dr. Altfeld raises some key points but none of them serve to prove his argument that MAD, as doctrine, was insane. He mentions several times the immorality of targeting cities with nuclear weapons. During World War II, the allies incinerated hundreds of thousands of civilians in the firebombing raids over Hamburg, Dresden and Tokyo so the reality of large numbers of dead "enemy" civilians was not something beyond the pale of the strategic planners at the time. The bombs dropped on Hiroshima and Nagasaki were rationalized by the fact that even larger numbers of both soldiers and civilians would be killed in an invasion of the Japanese home islands. This somewhat cold-hearted formulation follows the Just War theory put forth by Aquinas and Augustine in that the death of a relative few in order to win the peace is justified. Of course the massive and unprecedented power of nuclear weapons is something the Just War theorists never dreamed of and there is certainly room for legitimate debate on the subject. The Just War theory is not a legal document though, and as a signatory of the Geneva Conventions of course we have an obligation to minimize civilian casualties. However, as our past actions have demonstrated, it is sometimes difficult to shoehorn war into a moral construct. MAD assured deterrence with just the threat of a nation's complete annihilation. Holding the entire fabric of a nation at risk with nuclear weapons is a terrifying state of affairs and we were extremely lucky to have had leaders in place that sought not to upset the balance past the tipping point. A major reason this was so was the knowledge on both sides of the horrendous effects of a global nuclear war. There were a few who would continue to believe that a nuclear war was winnable, (Curtis Lemay, a notable example, was a living Cold War caricature and inspired the Gen Jack D. Ripper character in Dr. Strangelove) and of course this would be the official position of the two sides. Privately though, both sides knew the horrible consequences of even a limited exchange and obviously went to great lengths to avoid it.

A second point discussed in Dr. Altfeld's article was the "No Cities/Counterforce" doctrine. This doctrine is indeed morally superior to Countervalue but would only be effective if, after one side's conventional military had been destroyed by nuclear weapons, that side chose to surrender rather than launch, or threaten to launch the remaining strategic weapons at its disposal. It would make no sense militarily to surrender when you still have these assets still in the game. With the experience of World War II fresh in their minds, the nuclear strategists of the time clearly saw cities as legitimate targets. Once relative parity in strategic nuclear forces was reached, and we held each others entire nations

vulnerable to complete destruction, it was critical that the state of deterrence be maintained. The "no cities" doctrine could not stand because first use of nuclear weapons on the battlefield would most likely escalate. It's hard to believe, given the tension of the times, that either side would surrender before all its military capability was destroyed and this capability most certainly includes the strategic nuclear forces. Dr. Altfeld sites the Schlesinger report that dealt with a response to a hypothetical Soviet first strike against our deployed missile forces that would cause two million civilian deaths. What would the likely US response be to such an attack? We would certainly be in no mood to deal rationally with the Soviets and could easily have justified attacks on the major cities by including them as "leadership and C^2 targets". Our arguably overblown response to the September 11 attacks may give a hint to what the political and social climate would have been like in the event of a Soviet first strike, even one limited to our formations in Europe. The Al Qaeda attacks would pale to insignificance compared to a Soviet counterforce strike.

The bottom line is that MAD worked as it was intended and it's hard to argue with success. Monday morning quarterbacking of anything is easy and arguments will continue, but MAD was the best, most sane way to deal with an admittedly insane state of affairs.

A more detailed rebuttal would mean another entire article and I'd like to avoid that for now. As the editor of the NBC Report, I welcome dialogue and would like to see more responses to articles appearing in this magazine. I ask all in the community that feel the need to comment on certain pieces to send your thoughts to us as well as to the author so they can receive the attention they deserve. The dialogue is always valuable and as anyone who's spent any time dealing with WMD issues knows, there are many points of view on any of these subjects.

We look forward to your comments, thoughts and advice. Our body armor is on at all times.

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ENDNOTES

[1] MAJ Andrew Pache, "Why MAD was Sane." *NBC Report,* (Fall/Winter, 2005).

[2] The notion that MAD was a "fact of life" rather than a strategic choice, was argued most strongly by the late Wolfgang Panofsky. See "The Mutual-Hostage Relationship Between America and Russia," Foreign Affairs 52, (October, 1973).

[3] As I will note later in this paper, McNamara's avowed criteria for an "Assured Destruction" capability included the murder of one-half of the Soviet Union's civilian population.

[4] For the actual contents of Foster Dulles' speech, see, "The Evolution of Foreign Policy," Department of State Bulletin," 30, No. 761 (January 25, 1954): pp. 107-110; for the "clarifying article," see, "Policy for Peace and Security," Foreign Affairs 32 (April, 1954): p. 356. The enthusiasm which some of the critics of massive retaliation, such as Bernard Brodie, had for tactical nuclear weapons seems now to have been forgotten.

[5] "Policy for Peace and Security." (pp 108, 110).

[6] "Policy for Peace and Security." (p 356)

[7] "Statement of Policy by the National Security Council on Basic National Security Policy," Document 18 in The Pentagon Papers, Senator Gravel Edition, (Boston, Beacon Press, 1971) pp. 412-429, cited in Colin S. Gray, Strategic Studies and Public Policy, (Lexington, University Press of Kentucky, 1982) p. 36.

[8] Quoted in Lawrence Freedman, The Evolution of Nuclear Strategy, First Edition, (New York, St. Martin's Press, 1983) pp 77-78.

[9] Ibid., p. 288. See Also, Lord Ismay, NATO, the First Five Years, 1952-57, (NATO Archives). Updated March 15, 2001. passim.

[10] Quoted in Desmond Ball, "The Development of the SIOP – 1960-1983," Ch. 3 in Desmond Ball and Jeffrey Richelson, Strategic Nuclear Targeting (Ithaca and London, Cornell University Press, 1986) pp. 64-65.

[11] Ibid., p. 64.

[12] Roswell L. Gilpatric, "Address Before the Business Council, Hot Springs, VA, October 10, 1961." Documents on Disarmament 1961 (Washington, D.C., U.S. Arms Control and Disarmament Agency, 1962) pp. 542-550.

[13] Quoted in Desmond Ball, "The Development of the SIOP, 1960 – 1983," Ch. 3 in Ball and Richelson, Op. Cit, p. 64.

[14] For an analysis of the disruption to an enemy's attack planning that even a moderately effective defense can accomplish, see Michael F. Altfeld and Stephen J. Cimbala, "Turning Back the Clock: SDI and the Restoration of MAD," in Stephen J. Cimbala, Ed., Strategic Arms Control after SALT (Wilmington, DE, SR Books, 1989) pp. 75-94.

[15] McNamara's remarks to the Congress on the need for having "more than enough" are quoted in Freedman, Op. Cit, p. 241. His remarks on treating nuclear war "conventionally," made in his famous "Ann Arbor" speech, are cited in Freedman, Op. Cit., p. 235.

[16] Statement of Secretary of Defense Robert S. McNamara before the House Armed Services Committee on the Fiscal Year 1966-70 Defense Program and 1966 Defense Budget, February 18, 1965; p. 39.

[17] Freedman, OP. Cit. 246-247. According to Robert Jastrow, writing in 1984, during the twenty years, from 1964 to 1984, CEPs improved "…from about one mile in the early 1960s to 300 yards in the 1970s and 150 yards today." (p.41). He goes on to note that these declines in CEP have lead to a seven-fold reduction in the average warhead yield of the U.S. arsenal and a three-fold reduction in the average yield of the Soviet arsenal (p. 41) See Robert Jastrow "How to make Nuclear Weapons Obsolete," (Science, 1984, 92, #6, June, 1984) p. 41. For an excellent discussion of the development of MIRV technology, see Ted Greenwood, *Making the MIRV: A Study in Defense Decision-Making* (Cambridge, Mass.: Ballinger, 1975)

[18] Ten, according to the *Encyclopedia Astronautica* (http://www.astronautix.com/lvs/poseidon.htm), and several other sources.

[19] See Freedman, Op. Cit., Section 8, *Retreat from Assured Destruction*. Schlesinger's study is presented as an appendix in U.S. Congress, Office of Technology Assessment, *The Effects of Nuclear War* (Washington, D.C.: Government Printing Office, 1979). See also Paul Nitze, "Deterring Our Deterrent," *Foreign Policy*, Winter, 1976.

[20] Cited in William T. Lee, "Soviet Nuclear Targeting Strategy," Ch. 4 in Ball and Richelson, Op. Cit., pp. 86-87.

[21] Freedman, Op. Cit., p. 259. See also Colin S. Gray, *The Soviet-American Arms Race* (Farnborough, Hants: Saxon House, 1976).

[22] For a comprehensive discussion of the Soviet civil defense program see Leon Goure, *Civil Defense in the Soviet Union* (Greenwood Press, 1986 (reprint)). See also Leon Goure, *War Survival in Soviet Strategy: USSR Civil Defense* (Center for Advanced International Studies, University of Miami, 1976). For a detailed discussion of the role of ballistic missile defense in Soviet Strategy, see Steven P. Adragna, *On Guard for Victory: Military Doctrine and Ballistic Missile Defense in the USSR* (Cambridge, MA; Pergamon-Brassey's; 1987)

[23]See Paul Ramsey, *The Just War: Force and Political Responsibility* (Savage, MD; Rowman and Littlefield, 1968, 1983) pp. 153-155.

[24] By 1977, even the CIA was convinced. Their NIE of that year stated that "…the USSR was determined to achieve strategic superiority and to be in a position to win a nuclear war with the United States by 1985." Cited in Colin S. Gray, *The MX ICBM and National Security* (New York, Praeger, 1981) p. 124. For more specifics on Silo Vulnerability, per. se., see pp. 16-18.

[25] For an extensive discussion of the effects of risk-taking propensity on the decision to go to war, see Michael F. Altfeld, "Uncertainty as a Deterrence Strategy: A Critical Assessment," *Comparative Strategy*, (Vol. 6, No. 1, 1985).

Article cover picture from Hill, AFB Peace Keeper site http://www.hill.af.mil/icbm/lmpage/images/pkc.jpg

ICP Program Holds WMD Exercise in Estonia

Ms. Cindy McGovern
Defense Threat Reduction Agency

The wind was whipping off the Baltic Sea at Katarina Kei, a spit of land extending into the water just north of Estonia's capital city of Tallinn. As the small dinghy approached the beach, Jim Lizewski, a linguist from the Defense Threat Reduction Agency (DTRA), waved it off and was immediately taken into custody by Estonian law enforcement officials. While Lizewski was being interrogated on a remote Estonian shoreline, fellow DTRA linguist Tim Kimbrell was at the Tallinn International Airport being interrogated by Estonian customs investigators about suspected dual-use items in his checked luggage. A vacation gone bad? No. Both events were part of a carefully scripted series of field activities held in support of the weapons of mass destruction integrated field exercise conducted by the International Counterproliferation (ICP) Program.

The mission of the ICP program is to counter the threat of the proliferation of weapons of mass destruction, related materials and technologies across the borders and through the independent states of the former Soviet Union, the Baltic region and Eastern Europe

This WMD crisis response exercise was the second such exercise sponsored by the ICP Program and built on the first exercise held in Uzbekistan in November 2004. The seven-day Estonian event included a number of operational activities to include WMD response skills, refresher training and a pre-field tabletop exercise for 60 participants. After the refresher training, an integrated three-day field exercise was conducted in Tallinn and included an executive tabletop exercise for Estonia's Crisis Management Commission that built upon the field exercise scenario. Ruth Keipp, exercise director and ICP's program manager for the Baltics and Poland, said the exercise differed from the Uzbekistan effort because it incorporated actual as opposed to simulated sites where WMD trafficking occurs. "The exercise included many moving parts and was the first true integrated exercise for this Baltic country," Keipp said.

Keipp added that she and the other ICP program managers with the Defense Threat Reduction Agency have had excellent cooperation from the FBI and the Bureau of Customs and Border Protection (CBP) in the Department of Homeland Security who are joint partners with the Department of Defense in implementing this program. "We're fully integrated with both," said Keipp. In fact, the FBI sent technical experts from the Hazardous Materials Response Unit at Quantico and the Baltimore Field Office to assist in the law enforcement portion of the exercise. The CBP also sent personnel to serve as exercise

evaluators for the customs and border security scenarios.

In addition to the close working relationship with the FBI and CBP, the program managers coordinate with the Combatant Commands. "ICP fits into the DoD Security Cooperation Strategy and supports what the commands want to do in a specific country," said Army Lt. Col. Ken Deal, of DTRA's Counterproliferation branch, which has responsibility for the ICP Program. "The Department of State is also very tied-in in each country we're working in."

Jim Nixon, legal attaché for the U.S. Embassy in Estonia, explained that every year embassies receive a Mission Performance Plan. The plan establishes the priorities of each embassy. He said in the post Sept. 11 world, counterterrorism is a priority for everyone. "While Estonia does not have an indigenous terrorist threat, the ICP Program is the cornerstone of this embassy's counterproliferation, counterintelligence and security program. Security is synonymous with border issues," he said.

Nixon added that the Estonian justice and interior ministers were both new and the exercise provided a good opportunity for them to assess their needs and desire to continue with the ICP program. "The United States has transferred a lot of equipment to Estonia since 2000," he said. "If it weren't for this program, the Estonians would be working with antiquated equipment. This program has brought them to the next level and this exercise is the next logical step in the process.

"From an embassy and law enforcement perspective, we consider the ICP Program to be the brass ring of programs," continued Nixon. "We provide a lot of deliverables and also introduce the users to the equipment."

Ten Estonian agencies participated in the exercise including border guards, customs investigators, security police, criminal police, radiation protection board, rescue board, K-commando special operations,

demining center bomb squad, Prosecutor General's Office and the Crisis Management Bureau. The exercise was the first time many of these agencies had ever worked together and in fact their normal involvement with one another is nonexistent. The exercise provided an opportunity for the participants to not only exercise their individual responses, but learn how others could support them and how they could work together.

Keipp explained that the ICP program has been active in Estonia since 2000, conducted almost two dozen training courses valued at approximately $1 million and provided another $1 million in equipment. In addition to underwriting the November integrated exercise, the ICP Program also provided $155,000 in additional detection and monitoring equipment to some of the participating Estonian agencies.

The exercise actually kicked off on Oct. 27 with two days of refresher classroom training which included short courses in nuclear awareness, WMD dual-use equipment identification, documents of international trade, information management in an emergency operations center, decontamination and wearing of personal protective equipment and crime scene operations.

The third day featured a table top exercise with 12 short scenarios. Chris Hawley, a support contractor from Computer Sciences Corporation, encouraged participants to focus on each agency's best practices. "Then," he said, "discuss shortfalls in the current system. With each scenario discuss your challenges — each scenario should present a challenge to each agency. At the end of the day," Hawley continued, "Decide top three challenges for the scenarios."

The field exercise then, kicked off with Lizewski's capture at Katarina Kei. Lizewski was playing the part of a known fugitive who was at Katarina Kei to meet with an organized crime leader. The purpose of the meeting was to hand over chemical precursors and weapons. Lizewski's interrogation reveals the location of a possible safe house in Tallinn.

While the law enforcement personnel were interrogating Lizewski, a radiation sensor at the Tallinn International Airport's baggage claim area set off an alarm. The area was sealed off and the Estonian Radiation Protection Board called in to investigate. Shortly thereafter, Kimbrell is detained by Customs Personnel as he tries to enter the country with air purifying respirators with WMD filters.

Early in the morning of the second day both teams deployed to the Estonian Public Service Academy for a full day of events. Lizewski's safe house was secured by the K-commandos who found a clandestine lab which included chemical devices and traditional and improvised explosive devices. Several radiological sources were also discovered. At the other end of the academy, in a simulated freight consolidation warehouse, customs and border personnel review documents related to shipping transactions coming from North Africa, Central America and Iran.

Tim Kelly, a retired customs inspector who now consults for DTRA contractor CSC, explained the significance of the freight consolidation site. "People ship things all over the world," he said. "Shipments are routinely consolidated for economy, so this scenario is particularly relevant."

During the exercise, players discovered various elements, such as chemicals. They also found documents which confirmed leads developed from day one. "Checking money, suppliers and transportation may be dull stuff in the long-term," said Kelly, "but it's stuff that can cripple an organization."

Kelly added that he found the Estonian players to be a very professional group. "They compared notes on the essential pieces and determined why it was dangerous. By bringing together people with different specialties you can draw a more complete and cohesive picture of the overall operation. By combining the strategic with the tactical, you get an effort that can cripple a criminal organization," he added.

The third day saw yet another Tallinn venue, the Muuga Container Port about 17 kilometers outside of Tallinn, and the culmination of the exercise. From the investigation, it was not clear that a major WMD trafficking plot was unfolding. The Estonian customs and border personnel, working in conjunction with the security police, identified a suspicious container and made multiple entries to investigate the container.

While the majority of the players were at Muuga Port, the Crisis Management Team was standing up at the national 112 center (the equivalent of a U.S. 911 call center). The team had never met together before as a group in a time of emergency. Lacking then were any standard operating procedures or processes. The team included all the Estonian national operational agency directors designated for a WMD crisis incidence.

Deal explained that the future of the ICP program looks to more exercises such as the one in Estonia. "Many of the countries we're working in have completed many of the ICP Progam's training courses," he said. "An exercise like this provides more bang for the buck because we're now exercising capabilities. Events like this provide a new level of cooperation and integration."

Deal said the Estonia event was the most ambitious exercise the program has done so far. "We're only constrained by the host country and how willing they are to participate," he said. "In the case of Estonia, they saw the potential behind the exercise and acknowledged the importance of the scenarios they were presented with. It's encouraging to see the working relationship between the different Estonian agencies and their willingness to work together.

"This exercise is a capstone to what we've done in Estonia over the last five years," he continued, "but it's not the end. We'll take the lessons learned and apply them to the next location. Estonia is a model of success for the program."

Deal added that the ICP Program is flexible enough to tailor an exercise to meet needs of each country. In addition, recent legislation allows the program to now be applied worldwide.

Deal said that the ultimate goal of the program is to work regionally. "Combating the trafficking of WMD cannot be done unilaterally," he said. "For instance if country A won't let a material in, they may send it back to country B, where it originated. Then country B has to deal with it."

Just as the Uzbekistan exercise of 2004 served as a model for Estonia in 2005, this exercise will serve as the model for the next exercise anticipated to take place in 2006 in Azerbaijan. Planning is also just beginning for a regional exercise in Croatia which will include Croatia, Albania and Macedonia.

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Lightening the Load

Assistant Chief Constable Richard Stowe, Association of Chief Police Officers Terrorism and Allied Matters (ACPO TAM), talks to Gwyn Winfield about new PPE for the emergency services

London is a resilient city. Years of Irish Republican terrorism have enured the city to death and explosions; London just gets on with it. What was not appreciated was how a small twist in the scenario could change matters. Previously bombers came from beyond the sea – admittedly only the Irish Sea – and that gave an important psychological difference. The London bombers were home-grown; there was no foreign element, no jihadi mastermind who came from foreign climes. Instead these were four "locals" who decided to give their lives to take others.

This has caused a sea change in the way that the intelligence services look at local groups and also the way that the police are having to look at suspects. One of the police officers most directly affected by this sea change is the ACPO TAM CBRN policy lead, whose role is currently filled by ACC Stowe.

The 7 July bombings were also a wake up call for the civil responders, forcing them to look at some of the issues that they had already known about and requiring increased focus on others. The UK police, for example, have a "Steps 1,2,3" procedure which allows them to quickly judge whether the situation is a CBRN one – where there is one casualty (with no immediate cause) it is unlikely, with two casualties it is possible, with three casualties is likely to a CBRN incident. The explosions in the underground tunnels caused great clouds of particulate matter to be released, causing choking and eye watering which, when combined with blast/shock casualties should have set off the highest warning of Steps 1,2,3. Instead officers from all three services ran in to save lives – regardless of whether this was their defined role or not.

The initial reports from the London bombing raised concerns of a CBRN attack.

ACC Stowe agreed that there have been issues and that these were now being dealt with. "From a CBRN point of view, there was concern that it was a CBRN incident and I think that was caused by the soot and dust that came out of the tunnels as a result of the blast. Initially there were some concerns, but that proved not to be the case. As a service, the challenge that came out of 7/7 was that this was the first use of suicide bombing in mainland Europe and also the multiplicity of attacks. We have got to get our language very precise, between multiple attacks and simultaneity – which was what we had in three of the bomb attacks. So the

Deep tunnel rescue is a major challenge. ©NBCI

challenge for the emergency service was sorting through the confusion of multiple sites, multiple corpses and a combined response."

Another major challenge was the duty of care for staff. While it is commendable that service staff put their lives at risk to save others, there is still a need to ensure that they can do this with the best level of protection that is practical. "That is where the challenge lies for us," agreed ACC Stowe.

"Police officers and all the emergency services are almost micro-chipped into saving life, and the danger of rushing in is always there. This doesn't just apply to a CBRN incident; risk assessing any site is absolutely vital, whether that be as a result of a terrorist or other incident. We encourage our staff to do that. There was an element of that in the 7/7 attack, particularly in the tunnel. The one in Russell Square was more straightforward, in terms of scene, but deep tunnel rescue is a skill that the Fire Service quickly acquired. This has produced some interesting challenges for all the emergency services in getting people and equipment into tunnels, along tunnels and then back again."

In terms of CBRN, 7/7 happened at an auspicious time – right at the end of the MAIAT (Multi Agency Initial Assessment Team) pilot project that has been running in London. These had been light, manoeuvrable teams made up of the three UK emergency services who would, as the name suggested, be able to do an initial CBRN assessment; a MAIAT team was deployed and did attend the scene. The project came to an end and the MAIAT concept was officially shelved, yet there is still some debate about what follows MAIAT, although some areas of the country, such as Cheshire, have evinced an interest in seeing whether the concept would work in their area.

Assistant Chief Constable Stowe stated that work was ongoing to see what lessons could be taken out of MAIAT. "Where we go from here is all part of a series of seminars which we are attending. It is looking at initial response, who has responsibility for what action when they get there, what equipment is required, speed of response and on-arrival capability and capacity. 7/7 brought many of those things into sharp relief in the 'what if' scenario. If that had been a CBRN incident how would London have coped?"

Stowe suggested that the multi-agency part of MAIAT had become very clear during the 7 July bombing. "One thing that 7/7 showed us is that no one agency can cope on their own. That has become crystal clear after 7/7 in the CBRN field. It is too complicated for one agency; all three blue light agencies must be involved and cannot operate without the other. The police cannot operate without the Fire Service to decontaminate them or the health service to look after their health and welfare needs. I cannot deploy a police officer into a scene unless the Fire and Health Services are there. That is one of the few scenarios where that happens in policing; most of the time you can insert a police officer anywhere, as long as you have the ability to extract them. That's not the case with CBRN and the interoperability has been brought into stark relief because we couldn't get into the tunnels without the Fire Service."

The other major event that is going to shape UK policing is the 2012 Olympics in London. Athens required a sizeable NATO presence to maintain security and China is currently going through the pain of trying to secure an event that has tens of thousands of people attending. The UK lacks the authority of the Chinese

government, and ensuring that the event is CBRN-safe is likely to be a major challenge. ACC Stowe suggested that this wasn't a unique event for the UK: "If you go back to the G8 meeting in Scotland, numerous officers in Personal Protective Equipment (PPE) were deployed at that event and officers in PPE are deployed regularly at events in London which can be considered high profile. The planning for any major event has a CBRN element and the Olympics is no different, CBRN will be in the planning."

CBRN figures large in current procurement planning; as well as items like the Escape Hood, the police are interested in buying a new PPE ensemble and an automatic cordon device. "One of the areas in CBRN equipment that we are interested in, from a police perspective, is cordoning – do we need to look at some form of mechanical cordoning machine, what does that look like and how does that work – because that will save the deployment of large numbers of staff in full PPE.

"Also do we need to find a quick-donning PPE that allows a front line officer to go from being a normal response officer to a CBRN PPE officer in a matter of minutes? These are the capabilities that we are exploring at the moment; we need to talk to industry about whether these are commercially available off the shelf, or whether we need to move into some form of research programme."

The cordoning device is an interesting concept which would save a great deal of time and effort but requires an innovative solution. The cordoning vehicle would deploy at the scene and large barriers that require little to no observation would seal the street off. The exact shape of the vehicle and solution is unclear as the police are interested in innovative solutions. This is not to be a less lethal-type crowd control device – a slippery liquid, microwave energy, projectile glue – but a physical barrier that restricts free movement. While not necessarily a CBRN device, this would have other applications; it shows that police and emergency service personnel are beginning to think of solutions to CBRN problems that the NBC paradigm would never have encountered.

The PPE is a different procurement than the Escape Hood and the CR1 suit. The former is a piece of equipment that is in the final stages of procurement. "The Escape Hood is currently being tested and we haven't finished the work on that. A deployment strategy has yet to be decided but we are expecting that to come on stream soon," said ACC Stowe. The Escape Hood is a low cost, low weight item that provides an individual with a 10-20 minute (depending on exertion) window of opportunity to escape from the scene of a CBRN attack. It is not intended to be used to deploy at a CBRN incident. The CR1 is the latest suit for civil responders, manufactured by Remploy Frontline, and provides a high degree of protection to the user. The new PPE is the "light" to the CR1's "heavy"; it will provide a lower level of protection, but allow for quicker donning and less training. "The lightweight suit is a complete ensemble that can be quickly donned," said ACC Stowe. "It has a completely different purpose to the CR1 – it is not as robust as the CR1 for example, and that purpose is speed of access to a CBRN scene."

Speed of assessment is the key to lightweight PPE and is clearly a lesson that has come out of the London bombings. "Primarily it is about scene assessment," commented Richard Stowe. "Any scene we go to we risk-assess, not only in terms of CBRN impact, but in terms of all the other political and social issues. Our risk assessment process is broader than the Fire Service, for example, as they are looking at the hazard; we look beyond that. The purpose of a quick donning PPE – and the emphasis is on quick donning – is to get a police capability into a scene for a short period of time quickly. There is no intention of replacing the CR1, which will come later in any incident and allow us to work for a longer period in the hot zone."

ACC Stowe denied it was going to be anything as simple as a CBRN coverall with drawstrings and suggested that it was something that could be deployed in the boot of every officer's car, could be donned in seconds and would allow a working time of one to two hours. Protection is not the only piece of the procurement jigsaw – the Home Office is currently undertaking a study of suitable CBRN detection devices, the Fire Service are thinking about Detection, Identification and Monitoring (DIM) for New Dimensions Two, and the Ambulance Service is also looking at a detection and warning capability – albeit at a far lower level. It would seem that there is a real threat of duplicating DIM among the services and may require another look at the role of detection among responders. Since 7/7 showed that multi-agency operations were the way forward for CBRN events, why not have one service in charge of DIM?

The Fire Service would seem to be the natural heir to this, as they need detectors for environmental incidents, Toxic Industrial Chemical (TIC) spills, etc, freeing the police from the need for expensive detectors and expensive training. ACC Stowe disagreed: "I don't think so. This is still a crime scene and the identification of the agent involved is fundamental to the investigation. You do make a valid point, however, about three agencies turning up at the scene with three sets of DIM equipment. We need to clarify the roles and responsibilities. We need to clarify what we mean by DIM, as there are some challenges in the areas of what detection means, and what identification means – is that evidential identification?

"Additionally, there is the role of monitoring. Monitoring may go on for hours, days, weeks or months after an incident – and whose role is that? As our multi-agency work evolves, the rubbing points between agencies becomes clear and we are starting to begin the discussions of resolving those issues – and as you pointed out, the DIM question is one of those rubbing points.

That having been said, we have found a constructive working relationship with all the agencies involved to tackle this one."

Yet it is not just the cost of the detectors themselves that causes the problems; often it is the training burden that goes with it – and this is especially true with TICs detectors. TICs were the big issue for the past couple of years, and for many the solution to this was Inficon's Hapsite. Yet for all Hapsite's virtues it is still a piece of ruggedised lab equipment and the training burden on it does not lend itself to every CBRN trained officer being *au fait* with its workings. This is not just the case with Hapsite – biological detectors have a horrid training requirement, and to proliferate detectors throughout the force is also to proliferate training costs. Surely what is needed is a small cadre of specially trained officers complemented by response officers who have a far lower degree of detection – of the "it is harmful chemical, time to get out of Dodge" variety.

ACC Stowe suggested that it wasn't that simple: "When it comes to identification you will need to know, at some point, exactly what it is that you are dealing with; when that occurs is a moot point. From an evidential perspective the police need to know exactly what they are dealing with, but for the first 15-20 minutes that information is probably not required. So when it comes to scene assessment, detection that something dangerous is present is perhaps all that is required. As soon as you move into the world of specific identification then the training considerations are considerable and the ongoing cost of maintaining that training is self-evident. So we are well aware of the training cost and the implications, whether it be TICs or any other product. The question of when you need to know what it is, other than 'it is a nerve agent' or 'it is a chlorine based chemical' is something that we are working on and that links us closely with the Fire and Health Service. As Health needs to know what it is, for treatment purposes, Police need to know for evidential purposes and the Fire Service need a more general identification for search and rescue. What we need now is to find a way to work together to agree on that information, who provides it and how we get it."

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Supporting NATO's Multinational CBRN Defense Battalion

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Few organizations have faced as fundamental shift in focus as that faced by the North Atlantic Treaty Organization (NATO) in the post-Cold War era. The Soviet menace was history, replaced by the more nuanced and pernicious threat from rogue states, non-state actors, and terrorist organizations. NATO had earned the title of the most successful military organization in history, but had it outlived its reason for being? The members of the Alliance made critical decisions during the early to mid-1990s to adapt to the new environment by continuing to serve as Europe's primary security organization while expanding membership and taking on new roles.[1] One of the new missions, Combating Weapons of Mass Destruction (WMD), became a priority for the member nations of the Alliance. NATO required a healthy dose of transformation to meet the WMD threat; it needed to develop operationally effective and deployable chemical, biological, radiological, and nuclear (CBRN) defense forces that were both cost efficient, and maintained the NATO principle of burden-sharing.

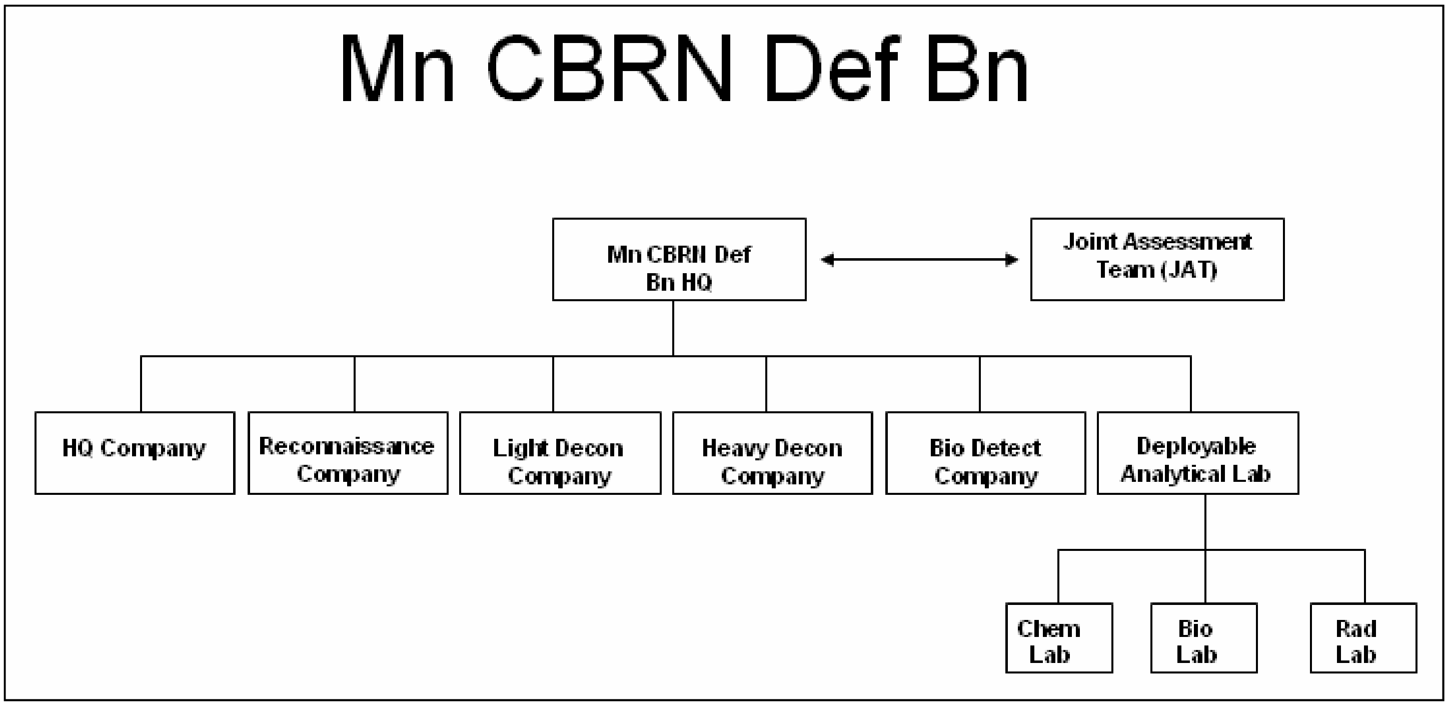
This article reviews the intent behind the formation of the NATO's premier rapidly deployable force, the NATO Response Force (NRF), and its corresponding CBRN defense element, the Multinational CBRN Defense Battalion (Mn CBRN Def Bn). First, the mission and organizational structure of the Mn CBRN Def Bn will be discussed. The article then shifts to exploring how US forces support the Mn CBRN Def Bn by looking at the role of the 20th Support Command chemical, biological, radiological, nuclear and high yield explosives (CBRNE) in supporting the Battalion. Finally, the article will provide a report on the 20th Support Command (CBRNE) participation in Exercise GOLDEN MASK 2006, the certification exercise for the Mn CBRN Def Bn for NRF rotation 7.

Modernizing NATO's Capabilities

Most of NATO's military focus during the Cold War was on combating an armored Soviet thrust across Central Europe. European defenses were primarily based upon heavy mechanized units, including a large reserve component, which were prepared to fight close to home. The old structure has been termed "heavy metal armies" by the current NATO Secretary General, Jaap de Hoop Scheffer.[2] Defense in place was a sound doctrine during the Cold War, but did not provide the proper structure for post-Cold War operations that required a more agile force. The NRF concept grew from a proposal from US Secretary of Defense Rumsfield in September 2002 for NATO to create a Rapid Reaction Force capable of operating outside of the European theater.[3] The NRF concept found a receptive audience across NATO and was formally adopted at the November 2002 Prague Summit. The NRF consists of land, air, maritime, special forces, logistical support forces, and CBRN defense forces, all trained and equipped to common NATO standards. NATO designed the NRF to execute a variety of missions, be rapidly deployable, and have the capability to operate in a CBRN environment.[4] Nations contribute to the force package on a rotational basis, with a six-month train-up followed by a six month on-call commitment to deploy.[5] Rotating forces decreases the burden on individual nations, and ensures that training and operational experience will increase across all of the nations, i.e. burden-sharing. Due to its' multinational nature, General Jones, Supreme Allied Commander Europe (SACEUR), intends to use the NRF concept to help transform NATO forces and capabilities to be more interoperable and expeditionary.

The first NRF rotation (NRF 1), consisting of 8500 personnel, was formally inaugurated in October 2003, less than one year after the concept was adopted at Prague. This force has greatly increased in capability and has a targeted end strength of over 20,000 personnel that are deployable to a theater within a five to 30 day window after receiving notification. The NRF can sustain itself for 30 days, or longer if re-supplied. The NRF achieved initial operational capability (IOC) in October 2004, following the successful train-up and certification of NRF 3.[6] NRF 6 is currently NATO's on-call force, and NRF 7 is in the training phase. Elements of the NRF have deployed operationally; providing humanitarian assistance to the victims of Hurricane Katrina and the earthquake ravaged areas of Pakistan.[7] The NRF is due to achieve full operational capability (FOC) when NRF 7 is certified, prior to October 2006.

CBRN defense has been at the forefront of NATO's military transformation. The Mn CBRN Def Bn grew



Mn CBRNE Defense Battalion Wire Diagram.

out of the five NBC Initiatives adopted at the Prague Summit. The Summit approved the formation of the deployable NBC analytical laboratory, NBC event response team, NBC center of excellence, NBC defense virtual stockpile, and disease surveillance system. Two elements, the analytical laboratories and event response teams, were merged into the Mn CBRN Def Bn concept at the suggestion of NATO's military staff. The Mn CBRN Def Bn reached IOC under Czech leadership in December 2003, and FOC in June 2004.[8]

The mission of the Mn CBRN Defense Battalion is to rapidly provide a credible Nuclear, Biological, and Chemical (NBC) defense capability, primarily to deployed NATO joint forces and commands, in order to preserve Alliance freedom of action in an NBC threat environment. The Battalion can respond to and manage the consequences of CBRN events. The Mn CBRN Def Bn will most likely deploy in support of the NRF, but it may be committed to supporting other NATO military elements, or supporting civil authorities.[9]

The Mn CBRN Defense Battalion was designed with the capabilities of conducting the following tasks:

- NBC reconnaissance operations
- Provide identification of NBC substances
- Biological detection and monitoring operations
- Provide NBC assessments and advice to NATO commanders
- NBC decontamination operations[10]

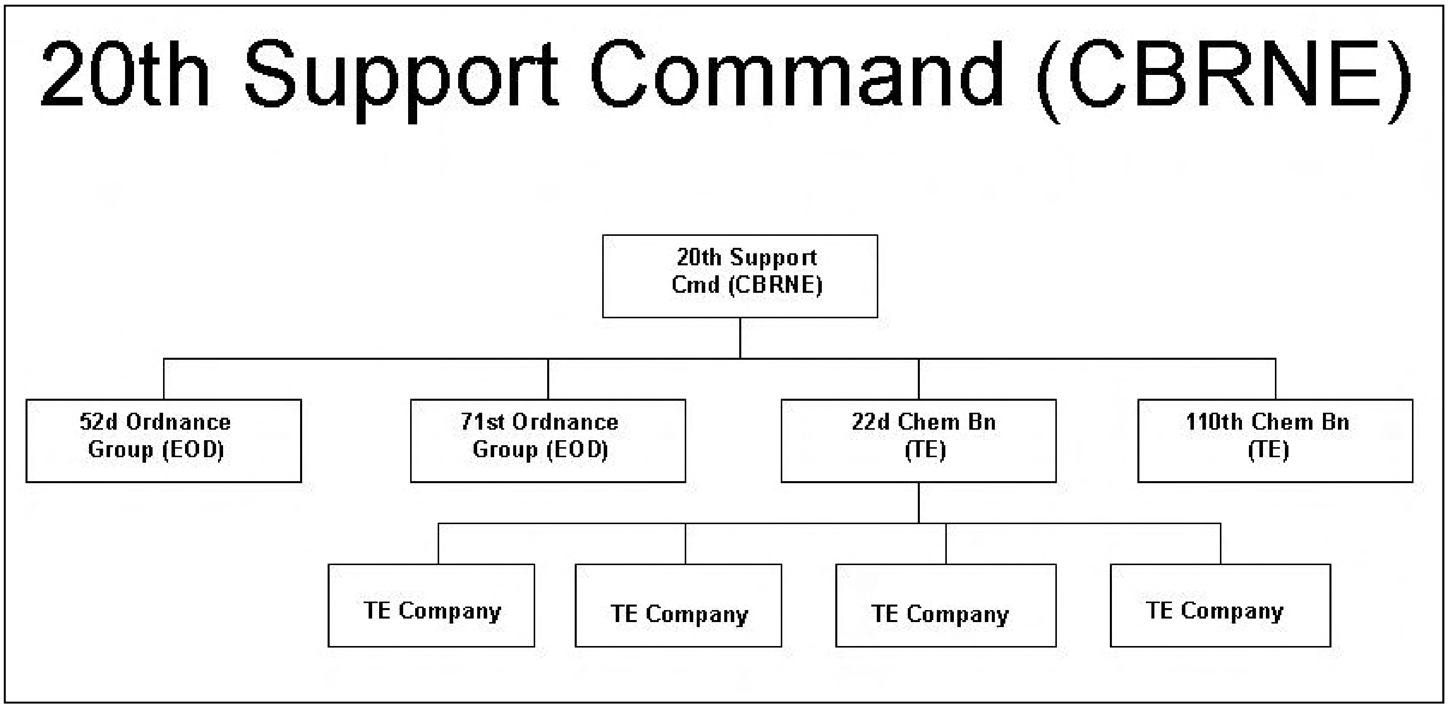
and has the following organization:

- Headquarters and Support Company
- Reconnaissance Company
- Light Decontamination Company
- Heavy Decontamination Company
- Biological Detection Company
- Deployable CBRN Laboratories[11]
- A Joint Assessment Team (JAT) (This is an independent team of specialists providing strategic assessment and advice to the Joint Commander)

NATO has developed a Combined Joint Statement of Requirements (CJSOR) to guide the formation of NRF components that meet the requirements and capabilities desired. The CJSOR is published and promulgated, and is followed by a Force Generation Conference, which is held annually. Member nations are able to offer capabilities (major units, individuals, equipment, etc.) at the Conference. This allows nations to participate in the Mn CBRN Def Bn (or NRF) to the extent they desire. Forces rotate as the on-call unit on six-month basis, following a six-month train-up and certification period.[12] Member nations are responsible for manning, equipping, and supplying their own forces, however, bilateral and multinational arrangements between the nations allow supporting requirements to be optimized.

US Support to the Multinational CBRN Defense Battalion

The 20th Support Command (CBRNE) is the successor to the US Army's Guardian Brigade, and was formed to provide the Army with a single organization that can "effectively train, integrate, coordinate, deploy, and manage its specialized CBRNE technical assets." [13] These specialized assets are in addition to the Corps- and Division- level assets that support battlefield commanders. The 20th Support Command (CBRNE) has four major subordinate organizations which are as follows: the 52d Ordnance Group Explosive Ordnance Disposal (EOD), 71st Ordnance Group (EOD), 22d Chemical Battalion Technical Escort (TE), and the 110th Chemical Battalion (TE). Additional EOD battalions and companies may also be added to the or-



20th Support Command (CBRNE) Wire Diagram.

ganization, as well as other specialized assets.[14]

Joint Response Team 1 (JRT-1) from one of the technical escort battalions was designated as the U.S. sampling team to support the NRF 7 rotation. Technical Escort units trace their lineage to the chemical weapons handling units long associated with the US chemical weapons program.[15] The current organization and equipment of the JRTs allow them to serve as multi-discipline units capable of deploying "task organized teams inside or outside the continental U.S. to conduct CBRN hazard characterization, monitoring, disablement, and elimination support operations."[16]

JRT-1 Exploiting a Clandestine Biological Warfare Agent Laboratory.

US CBRNE capabilities continue to grow and mature to meet the CBRNE threat. The national leadership made the decision to expand 20th Support Command (CBRNE) capabilities to allow the unit to "serve as a Joint Task Force capable of rapid deployment to command and control WMD elimination and site exploitation missions by 2007."[17] This new tasking will expand the mission scope of the 20th Support Command (CBRNE), adding to previously assigned missions which include the NATO support mission.

Certifying with the Multinational CBRN Defense Battalion

Each iteration of the Mn CBRN Def Bn must certify as mission capable during its six-month train-up phase prior to being placed in an on-call status. Exercise GOLDEN MASK 2006, the Mn CBRN Def Bn certification exercise for NRF 7, was conducted in the Bergen-Munster Training Area in northern Germany from 25 March – 4 April 2006 to evaluate the Battalion in eight areas. The areas evaluated included Reception, Staging, Onward-movement, and Integration (RSOI); execution of command and control; provide lead nation

JRT-1 Conducting a Ship Search.

support (Germany); conduct multinational logistics; execute force protection tasks; provide CBRN support to employed forces; support consequence management operations; support humanitarian operations within capabilities; and execute integrated laboratory operations.

Nine nations were represented at GOLDEN MASK 2006 as part of the Mn CBRN Def Bn: Bulgaria, France, Germany, Hungary, Norway, Poland, Romania, Slovenia, and the United States. Germany is the framework, or lead nation for the Mn CBRN Def Bn during NRF 7, and provides the majority of the battalion staff and support personnel. JRT-1 deployed as an integral part of the Deployable Analytical Laboratory and worked very closely with the deployable Hungarian biological laboratory, the Norwegian EOD team, and the German staff of the Deployable Analytical Laboratory for the duration of the exercise. GOLDEN MASK 2006 began with several days of integration training, as could be expected with a multinational exercise with different nations working so closely together as an operational unit. Upon completion of RSOI the Battalion deployed in a field training exercise (FTX) to the fictional country of Laperouse to directly support the Land Component Command (LCC), in this instance Eurocorps, in executing NATO's participation in a UN sponsored stabilization mission.

There were numerous scenarios conducted during the FTX portion of the exercise, which covered the next four days. The Mn CBRN Def Bn executed essential tasks including decontamination operations, tactical movements, consequence management operations, chemical and radiological reconnaissance missions, exercises involving civilians on the battlefield, and chemical, biological, and radiological sampling and analysis missions. These tasks not only tested individual and team capabilities, but tested the ability of the Battalion to integrate and command and control a unit made up of elements from nine different nations. Evaluators included CBRN experts drawn from the LCC and across NATO.

The role of JRT-1 is to conduct sampling operations in support of the field analytical lab in order to provide commanders with a rapid analysis of any suspected biological agents. JRT-1 conducted three evaluated missions during the FTX that tested its abilities to perform its role to NATO standards. The missions ranged from very simple to very complex, and were as follows: compliant boarding of a freighter suspected of transporting chemical/biological warfare agents, exploitation of an industrial-sized biological facility suspected of producing biological agents, and exploitation of a clandestine biological warfare agent laboratory. JRT-1 readily incorporated the supporting Norwegian EOD team, providing a robust Initial Entry Capability into unknown environments. All sampling missions met or exceeded NATO standards and allowed quality analysis by the Hungarian field laboratory. The focus of JRT-1's pre-deployment training was on executing sampling to established NATO standards, which paid dividends during the exercise. It was apparent that other elements of the Mn CBRN Def Bn had also focused on training to the NATO standards; paving the way for integration into an effective unit.

JRT-1 Inside an Industrial Biological Facility.

Overall, the exercise was a huge success for JRT-1 and the units and personnel from other contributing nations. The ability to conduct realistic training in a tactical situation provided the team with experience in how to effectively integrate the team with NATO forces. The most important facet of the training exercise was learning the capabilities, limitations and expectations of the other NRF-7 contributing nations, specifically the supported analytical lab and the supporting EOD team. Pre-deployment training was critical, however, there is no substitute for actually working together in a realistic and demanding exercise.

Conclusion

Combating WMD is one of the top priorities for the NATO member nations. Individually none of the nations can hope to effectively meet the world-wide threat. Collectively, NATO can share information, exchange best practices and technologies, and combine forces into an operationally effective package. The Mn CBRN Def Bn meets NATO's requirements for an operationally effective and deployable CBRN defense force. The structure of the Mn CBRN Def Bn allows all of the member nations to share in the burden of providing CBRN defense, improve their forces by taking on the best practices and best technology, and to make a positive contribution to the fight against WMD. US participation in NATO NRF is facilitating SACEUR's transformational goals.

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Captain Eric Larsen is a 89E officer currently assigned to 22d Chemical Battalion (Technical Escort) as a Joint Response Team Leader. His previous assignments include serving as the 3d Army/CFLCC EOD Plans Officer and Commander 75th Ordnance Company (EOD). He is a graduate of the Explosive Ordnance Disposal School at Eglin AFB, FL.

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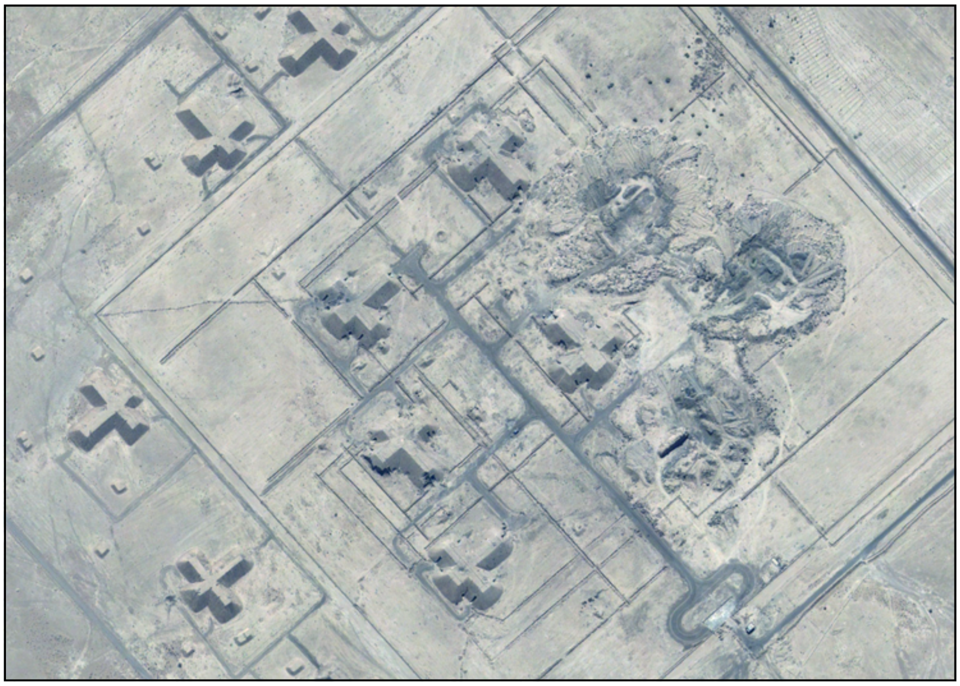
Brigadier John Deverell, CO 145 Brigade, talks to Gwyn Winfield about his time in Iraq with the Iraq Survey Group (ISG)

Mr. Gwyn Winfield
Editor, NBC International

This article was originally printed in NBC International magazine. The magazine focuses on all aspects of chemical, biological, radiological and nuclear (CBRN) defense.



GW: You were the senior British commander in the ISG for a period of time. Can you describe your role?

JD: I was the deputy commander to an American two star, Major General Keith Dayton – a US artillerist by origin. The group itself, when I was there at the start, was the most eclectic mix of scientists, experts, analysts, and a few generalists such as myself, and our job was, in regard to WMD, to go an find the kit.

One or two months in we were actually very surprised, from everything that we had read and what our remit was, not to find it. Then we started to look more closely at the intelligence that was actually found, and gradually we spent more time trying to work out what had happened to it, rather than where it actually was. An interesting experience…

GW: From the outside, the emphasis seemed to shift from being a CBRN detection role to being a detective or sleuthing one. How did the group deal with the culture change?

JD: It was not difficult because we had people within the group who were relevant as it transitioned – it happened gradually. Principally we had the British and US labs; we had the system in place to take the samples back, which we did on more than one occasion to make sure what we had was under international scrutiny. At every stage we had analysts and linguists on the documents that we had, looking for leads and evidence of what people had or had not been up to. The specialists were there to provide experience at every stage.

GW: It was a great surprise to everyone that there was not a smoking gun. How much "gun" – in the shape of chemical agents existing in far smaller quantities, or evidence of gun manufacture – was there?

JD: I was only there for the first few months; I came back at the stage where Dr Kay gave his report. I gave a press conference at MoD, and was able to show that we had found a lot of evidence of wherewithal to do this – we found clandestine labs, often concealed as private houses, a sample which could have been developed into BW and evidence of engines that the UN had declared were in breach. We never found evidence of the alleged mobile labs, for example. There were one or two people who gave evidence about manufacture – codename Curveball, for example – but the jury is still out over the accuracy of what he was talking about. We didn't meet all the expectations in our own minds; that's for sure. Yes, we

found the capability – to all intents we found the actual kit – but not enough to meet the remit that we set out to.

GW: I never bought the mobile lab idea – it smacked too much of super-villain, too much *Goldfinger*. But a lot of the Iraqi capability was mundane: individuals, scientists, etc. How many were still there on day one of the questioning, and who was noticed through their absence?

JD: The answer is I don't know. We were responsible for the questioning process for the high value detainees; we weren't the only people questioning them and they were farmed out, but there were key scientists that we spoke to a lot. Whether there were other key scientists who slipped away, I don't know. Personally, I think the answer is probably yes. We were hugely aided in the task by having a large number of ex-UN inspectors, when I was out there we probably had more ex-UNMOVIC and UNSCOM inspectors than the US did. They were a great help and hugely valuable as they knew, and sometimes knew as friends, the very Iraqi scientists we were speaking to. There was a relationship there and also a mutual respect as these people were all experts in their own field, so they were better placed to ask questions than I am.

What is going to happen in the future? I have no idea whether they are still detained or not. They all assured us that the kit had been destroyed. There was no question that the kit had been there in the early 1990s; we know that from evidence at Halabjah, but they said it had been destroyed and we wanted to know why they didn't tell us so we could have avoided the whole thing. They said they had to keep the whole façade alive because of the Israeli threat. We asked whether they saw the Americans as a greater threat, and one of them said that Saddam assured them that it wasn't going to happen; they weren't going to invade because "The Russians and French had promised them it wouldn't happen".

That underlies one of the lessons – the difficulty of trying to see things through other peoples optics. What seemed to us to be the obvious threat – show us you haven't got the kit and we won't invade – wasn't considered. What was alien to us, but would have been familiar to old Soviet observers, was the whole in-built secrecy. A lot of these scientists didn't realise what they were working on, in terms of its malign use. Every single component had layers of procedure, even nuts and bolts, meaning that the left hand didn't know what the right hand was doing. Saddam himself was probably thinking that he had more of a warlike capability than he had, because people had a vested interested in saying, "Boss, we are doing really well at this", when really they weren't either because they were frightened off asking for extra funding or because they hadn't made the expected breakthrough. The pressure was immense, and whole directorates were involved in the protection game and even fooling themselves. This came out through the UN inspectors' analysis; what could have been made, the numbers game of kit. One problem that became clear was the audit, the stock-take, the challenge of untangling what happened in the 1990s, especially because some of the Iraqis chose to destroy it unilaterally, not wait for us to destroy it. So we were trying to work out what had been destroyed, what had really happened, and come out with a correct analysis of how much kit there was. It was very tangled and we couldn't have managed without the ex-inspectors and even they, I am sure, have questions in their head as to what was destroyed at what stage and where.

GW: The other problem, I would have thought, was Bremer's rule number one: de-Baathification. When the same round-up of scientists was done after World War Two, Operation Paperclip, these people were treated with respect, as opposed to being cast out into the outer darkness.

JD: It didn't make life any easier. It wasn't our business – redirecting those people that had been involved into malign business into benign business for the Iraqi state. You need to bear in mind these scientists were important people who felt that the Iraq had a lot to give to the area. Ensuring that those people will be there for a peaceful Iraq – if de-Baathification means that those people will find it more difficult to find a job in Iraq as a scientist – will be difficult. I'm not sure

to what extent that benefits us in trying to encourage them away from malign purposes. Personally, I found them very impressive people, despite the history of the past two decades; unusually for an Arab country they were all taught English, there was a huge emphasis on learning and science – Baghdad had always been one of the three Arab centers of learning along with Damascus and Alexandria – they were well travelled, intellectually respected, open people who, orientated in the right way, have a huge amount to offer in the future. De-Baathfication, even if you understand the reasoning behind it, is a rather blunt tool and I don't know to what extent that ruined the whole process.

GW: In the West we tend to forget that many of these countries view scientists the same way that we did in the 1950s – as celebrities. Look at AQ Khan; in world opinion he is a criminal, but in Pakistan he is a celebrity. Prestige is all important in the Arab world and it will be a difficult process to ensure that these scientists are maintained at the same level that they were.

JD: We found that the US in the ISG had been very proactive in finding a way to deploy new scientists – not military scientists, but microbiologists, toxicologists, chemical engineers – who understood the practical application of their fields and these people were often lifted out of University as graduates or lecturers in the faculties and taken on in strength, as they could be deployed in a productive way. One thing that I got involved in when we got back in-country was whether we could utilise that same strength here, and we had some interesting conferences with people within MoD to explore how to identify these people in our Universities and see whether we can offer them a different occupation that the one that they would traditionally follow. When you look at wider warfare, you realise we are going to be more asymmetric. If you go back to World War Two you see how long it took before people with this sort of expertise were recruited and put to work – at Psyops, for example; recruitment of scientists, in the old category of 'funnies', is essential and you need to find someway of bringing them onside.

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BOOK REVIEW

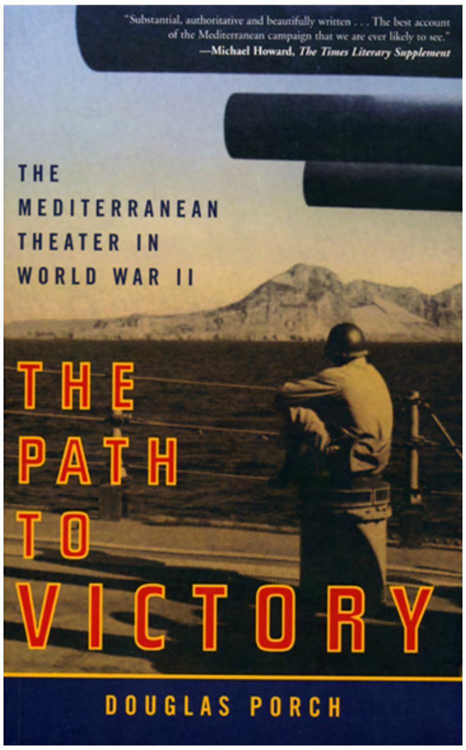
The Path to Victory: The Mediterranean Theater in World War II by Douglas Porch

MAJ Bret Kinman
United States Joint Forces Command

The *Path to Victory* is an insightful and enlightening look at the Mediterranean theater, one of the more "forgotten" combat theaters of the Second World War. Douglas Porch provides an excellent case study of the challenges involved in coalition warfare as well as the complexity of managing a theater of operations with multiple political and social challenges. Porch has written an extensive review of the strategy and political maneuvering that occurred in the theater, the key military and political personalities and finally the campaigns and battles that defined the theater. This work is useful reading for anyone interested in what was, in actuality, a key area of operations for the Allies during the war.

The Mediterranean theater is frequently overshadowed by Allied operations later in the war in Northern Europe. Arguably, the Mediterranean theater saw a longer, more complex campaign by Allied forces and against a more equal version of the German military. This is not to discount the difficulty of operations in Northern Europe after June 1944. However, by then the full weight of US industrial capacity was in play, while Germany faced steady degradation of its industry and the large scale loss of German military expertise and material on the Eastern Front.

Upon initial glance, the Mediterranean theater saw the first large scale "blooding" of the American Army and its leaders. Dwight Eisenhower, Omar Bradley, George Patton, and Mark Clark among others experi-



enced their first tests as leaders at the campaign level of warfare. Further, the theater allowed both the US Army and Navy to gain invaluable operational and tactical experience. The Mediterranean also saw British Army leaders exposed to modern combat rather than the colonial security operations they had mostly been accustomed to. The British Army experienced its first taste of battlefield success in the theater. Following the setback at Dunkirk and indeed after several defeats in North Africa by Field Marshall Rommel, the British victory at El Alamein in 1942 gave Churchill a needed triumph. Finally, the theater represented the final stages of the British Empire, and its subsequent eclipse by the United States.

The political backdrop of the Mediterranean also represents some of the most complex challenges that Allied leaders would face. Both sides dealt with unpredictability in allies and enemies. The Germans had to deal with an Italian nation and Army that was often suspect and hence unreliable, yet the Germans relied upon the Italian nation and military for a significant part of its southern defensive needs. Alternatively, the British and Americans had to first learn to deal with each other and their associated national strategic goals, the means to achieve those goals and differing military styles and operations. Yet nearly simultaneously, both Allies had to construe where French loyalties would lie. The French government in Vichy had made a deal with their German occupiers to acquiesce to German desires in Western Europe. The French exile leaders, to include much of the remaining French military outside of France, of course did not concur with the Vichy governments actions. Certainly, this complicated matters in North Africa; which French units would fight the Allies? Would they have a choice? Given the possibility of further action by the Germans in the French homeland, no actions were foregone.

Porch sets to sort all of these overlapping and competing facets of the theater. He further lays out the broader context of the conflict that faced the United States and Britain in the early years of the war. Accordingly, operations in the Mediterranean were a crucial interim measure. As Porch points out early in his book:

"My argument is that it was impossible for the Western Allies to transition successfully from Dunkirk to Operation Overlord without passing through the Mediterranean. That theater was critical in forging the Anglo-American alliance, in permitting allied armies to acquire fighting skills, audition leaders and staffs, and evolve the technical, operational, tactical, and intelligence systems required to invade Normandy successfully in June 1944. Overlord was rehearsed in North Africa, Sicily, and Italy. By 6 June 1944, the Mediterranean had worn down and ultimately dismembered the Axis." [1]

The United States military favored a direct assault onto the Northern European mainland as early as possible, with 1943 as the initial target. The British preferred a less direct strategy for defeating Hitler, the memory of the attritional struggle of the First World War still fresh in many senior British leaders' minds. Churchill and British military leaders preferred what is often termed a "peripheral" strategy of working into Germany through the Mediterranean. The British also preferred a Mediterranean strategy as a way to ensure British access through the Middle East to British holdings in India and the South Pacific. Certainly neither nation was truly prepared for an invasion of Northern Europe in 1942. American industry was just beginning to shift over to large-scale wartime production, and was not able to fully meet the demands of both the Pacific and European theaters. Nor was either nation's Army adequately sized, structured, equipped or trained for such an undertaking.

The challenges of the theater are central to the book, and to a broader understanding of challenges posed to both Allied and German forces. Even today, the overall expanses of the Mediterranean Sea along with its key geographical points which define access into and through the area pose operational and tactical challenges. The theater required a high level of interaction among air, naval and land forces in order to achieve anything other than tactical success. The German and Italian military benefited from short lines of communication, operation and supply as compared to the Allies. Yet the Axis also suffered from limited naval presence, which led to an inability to adequately contest the waters and therefore consistently supply the Axis forces in North Africa. Additionally, the demands of the Eastern Front limited available air assets needed to support naval operations and were thus able to provide only a limited ability to resupply German and Italian forces in North Africa. Nevertheless, German and Italian units in Tunisia were able to retain a line of support running back through Italy.

All of North Africa, from Morocco to Egypt was available to that side which could control it. The British however, held several key points in the theater. The possession of Gibraltar gave the British titular control of Atlantic access into the Mediterranean basin. Additional British control of Crete, Cyprus and Malta gave the allies a set of operational bases to facilitate operations. Finally, British control of the Suez Canal ensured British access to the Far East and raw materials; and ensured a second access point for resupply for North America and England, versus the cost of an extended and perilous trip around the African Continent. In each case the Royal Navy was a critical asset, and one that performed superbly throughout the theater and the campaign overall. The Royal Navy was able to buy time for the Royal Air Force and British Army to develop, train and equip in order to fight the Germans and Italians in North Africa.

The early parts of the campaign saw tactical engagements between German and Italian forces centered in Tunisia and Libya on one side; and British forces centered in Egypt, on the other. This early stage culminated in the Battle of El Alamein, a victory for the British. These early conflicts were conducted in the eastern part of North Africa and presented the German forces a unidirectional threat. Subsequently, the American military landed in Algeria under Operation Torch, and after consolidating its force and sorting out Free French and Vichy forces, began eastward movement to engage the Germans from the west. The American Army encountered initial tactical setbacks such as at Kasserine, but never suffered a significant operational defeat. The constant pressure from two well-supplied armies against the logistically deficient German forces led to the inevitable surrender of the remains of the *Afrika Korps* in May 1943.

From North Africa, the allies began to plan and execute operations in Sicily and the Italian mainland. Here, the British and Americans faced more difficult terrain, and a more prepared German and Italian defense. The Italian campaign, begun in September 1943, is frequently derided as a sideshow, and an unnecessary adventure diverting attention and effort from the upcoming Overlord operation to enter Northern Europe. The Allied effort to move up nearly the entire length of the Italian peninsula devolved into a grinding attritional struggle. The Allied forces attacked north, through craggy mountain ranges and across rivers. In addition to the challenges of the terrain, the German Army had prepared a series of defensive lines, with concrete bunkers, well supplied with minefields, heavy machineguns and presited mortars and artillery. As Porch points out:

"The grueling nature of a campaign fought out in impossible terrain, against concealed enemies, in debilitating heat or anesthetizing cold, gave rise to the belief that alternatives to Italy must have existed, ones that would have utilized Allied resources and manpower more efficiently in places of greater strategic significance. Indeed, Italy more often suggested the stalemate on the Western Front during the First World War rather than the sweeping advances and

retreats characteristic of the Second. Salerno, Cassino, Anzio, the battles on the Gothic and Winter lines stood as symbols of heroic yet mismanaged and unnecessary sacrifice." [2]

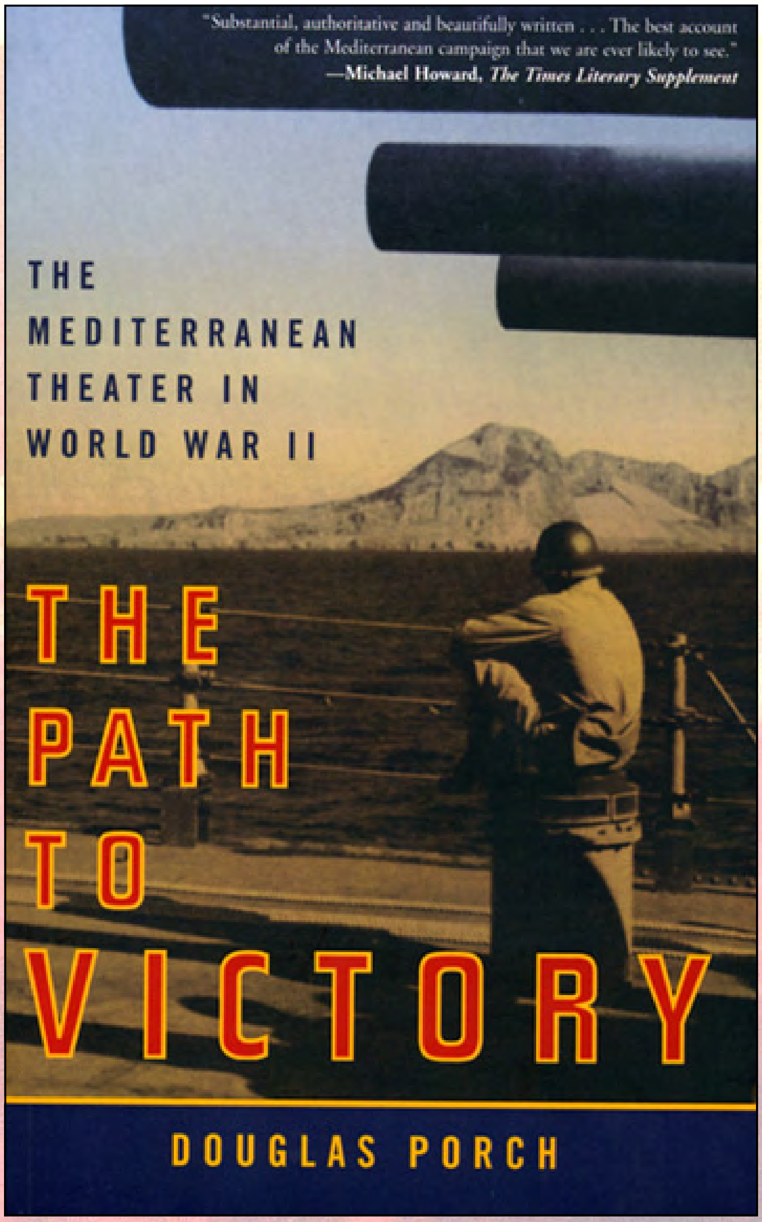
The Italian campaign was the longest Allied effort of the war, lasting "602 days from 9 September 1943 to the surrender of 2 May 1945." [3] Further, the Italian campaign was a key part of the Allied overall effort to defeat the German military and Nazi regime. The Italian campaign occupied 400,000 German troops in Italy, along with additional German units in Greece and the Balkans-totaling nearly one-fifth of German ground forces. [4] Italy and indeed the Mediterranean represented a critical theater for the Allies in the interim between the Allied entry into the war and the capstone of the Overlord invasion in June of 1944.

The Mediterranean Theater was, as Porch argues, the only place the allies could engage the Axis in Europe before 1944. [5] The campaign there allowed the Allies to build combat power, develop combat experience among its tactical and campaign level units, validate tactics and procedures and perhaps most importantly, preserve the alliance between the British, United States and Russia. Porch has written a detailed and inherently readable history of this often overlooked theater of World War 2. This book is helpful in understanding the complexities of political and strategic planning as well as grasping the challenges of the campaign or operational level of warfare. Finally, *Path to Victory* provides a valuable survey of this theater and its rather undervalued role on the Allied victory in World War 2.

Major Bret Kinman is a FA52 officer currently assigned to the United States Joint Forces Command J354 Anti-Terrorism/Force Protection. He was previously assigned as a student at the Naval Postgraduate School, Department of National Security Affairs to the USAREUR G3 Executive Office, and to the USAREUR G3 Force Protection & Anti-Terrorism Division. He has a B.A. in Political Science from North Georgia College and a M.S. in National Security Affairs from the Naval Post Graduate School. His email address is bret.kinman@jfcom.mil.

ENDNOTES

[1] Douglas Porch, *The Path to Victory: The Mediterranean Theater in World War II*, New York, Farrar, Strauss and Giroux, 2004. pp. xii-xiii
[2] Ibid, pp. 653-4
[3] Ibid, p. 653
[4] Ibid, p. 656
[5] Ibid, p. 671



The Nuclear and Counterproliferation Officer Career Field

An FA 52 Primer

LTC Robert Kolterman
United States Army Nuclear and Chemical Agency

The Nuclear and Counterproliferation Officer Career Field has about one hundred and fifty officers from the rank of major to colonel. Our assignments are primarily in two areas, operations staff support and scientific research and they are found both inside the DoD as well as within other agencies such as the Department of Energy. Since the early 90's and the beginning of the Intermediate Range Nuclear Forces Treaty, the Army has not had any nuclear weapons, but the requirement for competencies in nuclear operations and counterproliferation research still remains. This requirement manifests itself in two general ways, nuclear operations and force protection. The former, operations, is simply maintaining the expertise for nuclear weapon employment to ensure detailed analysis prior to any decision to request use of a nuclear weapon. The latter concerns protection of our forces from the consequences of any use, friendly or enemy, of a nuclear weapon.

It should be emphasized that neither the Army nor the DoD are proponents of the use of nuclear weapons. On the contrary, nuclear weapons are of little military use, particularly given our National values and strategic objectives, and their value lies mainly in their deterrent effect. Nevertheless, the fact that the weapons exist, requires that we maintain preparedness to deal with real and potential threats. Thus, I'd like to talk about the two areas of assignment for FA 52's, operations staff support and counterproliferation related scientific research and how competency in these two areas maintains the Army's relevance in nuclear operations.

Operations staff support

This primarily refers to the expertise needed for the employment planning and targeting of nuclear weapons but also includes the detailed understanding of weapons effects in order to protect personnel and equipment. Understanding the actual physics behind a weapon detonation is critical to ensuring appropriate employment and its related effects on the battlefield. The Army FA 52 career field produces officers well versed in these weapons effects and probably more importantly, with a keen understanding of the effects on the soldiers and civilians in the immediate area, plus the effects the detonation will have on the ground commander's scheme of maneuver. It is the ground forces which operate in and around the area and often remain in the area following armed conflict (Hiroshima/Nagasaki, Korea, and Afghanistan/Iraq to name a few) and therefore must literally live with the effects and aftermath of any nuclear weapon employment. Just like any other weapon, effects *affect* anyone, friendly, enemy, or civilian. What's more, these effects can be long lasting and, of course, devastating over a large area. From my personal view, it is this expertise and advice, and its application during operational planning, which will help forestall the nation from employing a nuclear weapon. I say this because of the overwhelming effect relative to the types of adversaries we see today. In other words, it is not necessary to hit a fly with a sledge hammer, especially if the collateral damage prohibits a functioning civil infrastructure.

Counterproliferation related scientific research

Keeping up with technology is critical both to advance US capability (nuclear or non nuclear) but also to keep ahead of adversaries and potential adversaries. Technically and scientifically proficient FA 52 officers work both inside and outside the DoD, doing highly relevant, cutting edge research in weapons effect and other nuclear related phenomena. Maintaining US research serves not only to improve our nuclear capability but to educate on how to better protect our forces against given threats. For example, the study of different types of fission devices helps us understand what adversaries may be capable of and therefore it makes it possible to identify measures we may take to mitigate the effect of these devices. My previous position in DTRA in detection technologies was focused on developing capabilities to detect hazardous material for military use as well as civilian application in protecting the homeland.

To properly staff these positions, the career field is composed of about one hundred and fifty officers from the rank of Captain to Colonel. Officers enter into the career field as senior Captains or newly promoted Majors and are sent to obtain an advanced degree in nuclear physics or National Security Studies, and then assigned to senior staffs (combatant commands or Army Staff) or within the DOE or joint/defense directorates. There are exceptions to this, but by and large this career track is the basis for sustaining qualified officers. Occasionally, officers are brought into the career field after obtaining the rank of Major or Lieutenant Colonel. Depending on the circumstances, advanced schooling may not occur. Nevertheless, the officers bring with them a great deal of operational experience which contributes to their unique qualifications. As one might imagine, not all career field positions demand an advanced nuclear degree. Even positions within the scientific research area, such as those in the national laboratories, do not necessarily require a doctorial level of understanding as these positions are surrounded by scientists both civilian and military. The goal is a balanced officer capable of competently considering nuclear operations and research requirements and incorporating them into DoD capabilities or needs.

I hope I have been able to share some insight into a little known career field within the Army. Further, I hope I have instilled some confidence that the military maintains a professional and deliberate watch over the awesome capability with which we have been entrusted. We all hope, and certainly wish, there will not be another use of a nuclear weapon, but as long as our arsenal contains them and adversaries threaten their employment, the Army and our sister services quietly and competently remain ready.

LTC Robert Kolterman is a FA52 officer assigned to USANCA as the Chief of Training and Operations. He has a BS in Physics from Lock Haven University, a Masters in Management from American Military University and a Masters in Strategic Studies degree from the US Army War College. He also served as Chief of Development of Detection Technologies while assigned at the Defense Threat Reduction Agency (DTRA).
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NUCLEAR AND COUNTERPROLIFERATION OFFICER
FA52

U.S. ARMY NUCLEAR AND CHEMICAL AGENCY
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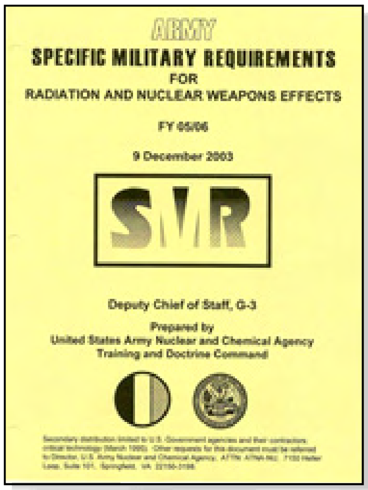
Combating WMD Resource Page



ARMY
SPECIFIC MILITARY REQUIREMENTS
FOR
RADIATION AND NUCLEAR WEAPONS EFFECTS
FY 05/06
9 December 2003
SMR
Deputy Chief of Staff, G-3
Prepared by
United States Army Nuclear and Chemical Agency
Training and Doctrine Command

Specific Military Requirements (SMR)

The FY 08/09 SMR preparation process began with a two-day meeting at USANCA on 18-19 January 2006. COCOMS attendees discussed their NWE needs and gaps following presentations by AFMIC and DIA. USANCA is now waiting for JRO guidance on their radiological and nuclear Quick Look.

Related 2007 Technical Meetings

25th Hardened Electronics and Radiation Technology (HEART) Conference TBD 2007
2007 DoD E3 Program Review 17 May 2007
2007 IEEE Nuclear and Space Radiation Conference (NSREC) TBD 2007
POC is Mr. Robert Pfeffer @ 703-806-7862

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FA52 Courses of Interest

Theater Nuclear Operations Course (TNOC)

TNOC is the only course offered by a Department of Defense (DoD) organization that provides training for staff officers and DoD civilians at Joint, Combatant Command, and Service levels who are required to conduct or support theater nuclear planning. The course teaches students the skills and knowledge necessary for theater nuclear planning, to include the integration of nuclear and conventional fires, weapon system delivery capabilities and limitations, determination of collateral damage effect, determination of force protection and warning measures, and the theater nuclear plan approval and execution process. The course number is DNWS-RO13 (TNOC). Call DNWS at (505) 846-5666 or DSN 246-5666 for quotas and registration information.

Joint Planner's Course for Combating WMD (JPC)

For DoD staff officers with combating WMD responsibilities.
POC is LtCol Morales at 703-325-1294.

Nuclear and Counterproliferation Officer Course (NCP52)

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UCPOG Calendar—2006

Date	Event	Location
12 October 2006	Annual UC Brief to the Nuclear Weapons Council, Standing and Safety Committee (NWCSSC)	Pentagon, Washington, DC
16-20 October 2006 (tentative)	UCPOM 2006-02	TBD

For more information contact:
Patrick Starke, LT/USN, Lead Project Officer
(703)325-4350 or patrick.starke@dtra.mil

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